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TA 665 (1938)

USDA TECHNICAL BULLETINS

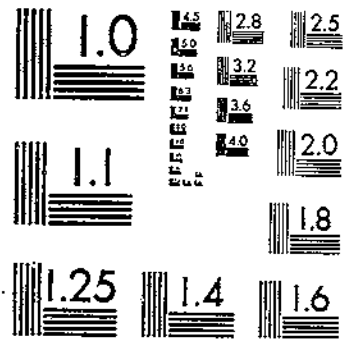
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RELATIONSHIPS AMONG PRODUCTION AND GRADE FACTORS OF BEEF

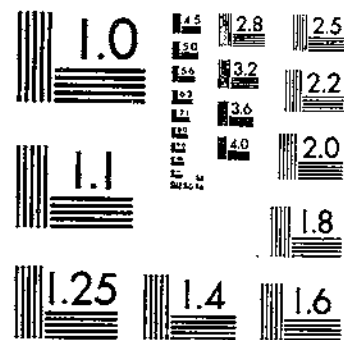
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

RELATIONSHIPS AMONG PRODUCTION AND GRADE FACTORS OF BEEF¹

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United States Department of Agriculture, Bureaus of Agricultural Economics and Animal Industry, in Cooperation With the Agricultural Experiment Stations of Arkansas, Colorado, Illinois, Indiana, Iowa, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Mexico, Ohio, South Carolina, Texas, Virginia, West Virginia, and Wyoming.³

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INTRODUCTION

Widespread interest in the grading of meat animals and meats exists in the United States. This interest occurs not only among producers and the livestock and meat trade but also among consumers. It has increased greatly in recent years, notably in the last-mentioned group.

The producer's interest in this subject is broader than that of anyone else. He is concerned not only with production factors, such as

¹ Received for publication March 29, 1938.

² A. T. Edinger, representing the Bureaus of Agricultural Economics and Animal Industry; D. J. Slater, representing the Bureau of Agricultural Economics; and F. G. King of the Agricultural Experiment Station of Purdue University, Ind., representing the cooperating institutions as a whole, had the major responsibility in grading the animals and carcasses. The National Live Stock and Meat Board assisted in making available the services of the general representative of the cooperating institutions. Acknowledgment is also made of the courtesies extended by representatives of the meat-packing industry at whose establishments many of the experimental animals were slaughtered. Mrs. Terrie G. Johnson and Mrs. Edna V. Stealy of the Bureau of Animal Industry assisted in making the statistical analyses of the data.

³ In Arkansas the cattle were fed at the State Agricultural and Mechanical College at Jonesboro; in Louisiana, at the Iberia Livestock Experiment Farm, Jennerette; in Missouri, at Sni-a-Bar Farms, Grain Valley, and at the State Station at Columbia; in Montana at the U. S. Range Livestock Experiment Station, Miles City; in New Mexico, at the Tucumcari Field Station, Tucumcari; in Texas, at the Big Spring Field Station, Big Spring, and King Ranch, Kingsville; and in West Virginia, on the farm of R. H. Tucker, at Lewisburg. In the other 11 States the production phases of the experiments were conducted at the respective State agricultural experiment stations.

initial weight, rate and economy of gain, total gain, and final weight, but with animal grades and grade factors and the relationships among the production and grade factors. He is also indirectly concerned with the relationships between the slaughter-animal and carcass grades and the significance of carcass grade from the viewpoint of the consuming public.

The buyer of animals for slaughter is directly concerned with the relation between slaughter-animal grade and carcass grade. Together with the retailer he is vitally interested in the reaction of the public to the different grades of meat. The public, in turn, seeks a reliable practical index of the variations in the quality of the meat it buys and apparently, to an increasing extent, is finding that the grade is the most satisfactory guide available at this time.

For a number of years, in the livestock and meat industry and among research workers, there has been an appreciation of the necessity of ascertaining the factors affecting the grade of meat animals and meats and of determining their relationships and relative importance, and how to control them. An excellent opportunity for conducting studies on the various phases of this problem, as it relates to cattle and beef, was afforded in connection with the national project, Cooperative Meat Investigations. This project was begun in 1925, and the cattle and beef-carcass grading studies in connection with production studies have been conducted as a phase of the investigations from the beginning.

In this phase of the cooperative meat investigations, the purpose was to determine the relationships (1) of certain production factors, such as initial weight, final weight, total gain, and rate of gain, to composite grade or the grade of the individual and to certain grade factors of the animals and the carcasses and (2) among grade factors themselves. Economy of gain, although important, could not be included in the study, owing to the special method of analyzing the other data.

EXPERIMENTAL PROCEDURE

Data from 2,073 cattle used in experiments conducted in 1925-26, 1926-27, and 1927-28 were considered in making this analysis. Many experiments were represented, varying greatly in nature and main objective. In consequence, there was marked variation among the cattle in age, breeding, grade, rations fed, weights, gains, and other factors. For example, the variation in breeding is shown by the fact that there were 37 purebred and 120 grade Aberdeen Angus, 134 grade Brahmans, 38 purebred and 1,316 grade Herefords, 3 grade Holsteins, 19 purebred and 315 grade Shorthorns, 14 crossbreds, and 77 scrub cattle. The ages of the cattle as feeders ranged from a few months to more than 3 years. Eighty-eight different rations were used. As a result of the variations in breeding, age, rations, and other factors, it is believed that the group of 2,073 animals was a good representation of commercial beef cattle.

Of the cattle used there were relatively large numbers of steer calves, yearling steers, 2-year-old steers, and heifer calves. The numbers were sufficiently large to justify separate and comparative consideration of the data on these four groups. In classifying the feeder cattle according to age those less than 1 year old were desig-

nated as calves, from 1 to 2 years old as yearlings, and from 2 to 3 years as 2-year-olds. As a basis for settling a few questionable cases, an arbitrary weight of 550 pounds was adopted as a dividing point between calves and yearlings. Those animals with weights of less than 550 pounds were designated as calves; of 550 pounds or more, as yearlings. Most of the calves were placed on experiment when they were about 7 to 9 months of age, the yearlings at about 19 to 21 months, and the 2-year-olds at 31 to 33 months.

In the grading work, each animal was given detailed consideration with respect to various visual characteristics, regarded as grade factors, first as a feeder, next as a slaughter animal, and finally as a dressed carcass. This work was done by a committee of three qualified men representing the cooperating agencies. The average of the opinions of the three graders was taken in each instance as the official grading. Grading charts, which were developed and adopted by the cooperating institutions, were employed in the work.⁴

The major grades used in this study were previously established and recognized officially by the United States Department of Agriculture. There are six major grades for feeder steers and heifers (fig. 1) and seven each for slaughter steers and heifers and beef carcasses (figs. 2-4). Those for feeder cattle are as follows: Fancy (90.01-100); Choice (80.01-90); Good (70.01-80); Medium (60.01-70); Plain, formerly designated as Common, (50.01-60); and Inferior (40-50). The grades for slaughter cattle and beef carcasses are: Prime (90.01-100); Choice (80.01-90); Good (70.01-80); Medium (60.01-70); Plain, formerly designated as Common, (50.01-60); Cutter (40.01-50); and Low Cutter (30-40). Each major grade is divided into three subgrades: high, average, and low. The feeder-grade names differ slightly from the corresponding grades of slaughter cattle and beef carcasses. A Prime carcass or slaughter animal is regarded as corresponding to a Fancy feeder, Choice carcass or slaughter animal to Choice feeder, Good to Good, Medium to Medium, Plain to Plain, and Cutter and Low Cutter to Inferior.

Particularly in connection with the slaughter-cattle and beef-carcass grading, the grade factors were weighted in general as described for slaughter cattle by Slater.⁵ However in grading feeder cattle the factors regarded as indicative of the conformation, finish, and quality of the respective slaughter animals and carcasses at the end of the feeding period were the primary considerations.

In the study of data on the four groups of cattle mentioned previously, carcass grade instead of slaughter-cattle grade was considered in relation to feeder grade, total gain, and other factors. This was done because (1) carcass grade obviously is a more direct measure of the quality of the product than is the grade of the animal on foot, and (2) it is believed that normally carcass grade is judged with greater accuracy than slaughter-cattle grade. This belief is supported by the results of a supplementary study of the data on 100 individuals selected at random from the 2,073 cattle considered in this bulletin. The supplementary study showed somewhat closer agreement, on the average, among the three members of the committee in grading the

⁴ Copies of feeder- and slaughter-cattle grading charts, similar to those used in the present study, are included in the following: SLATER, DON J. MARKET CLASSES AND GRADES OF CATTLE. U. S. Dept. Agr. Bull. 1464, 88 pp., illus. 1927.

⁵ SLATER, DON J. See pp. 22-24 of citation given in footnote 4.

beef carcass than in grading the respective slaughter animal. As is shown later, however, there was a high correlation between slaughter-cattle grade and carcass grade. Therefore, the reader may consider the carcass-grade relationships reported here as indicative of the results that would have been obtained had the slaughter-cattle grades been used.

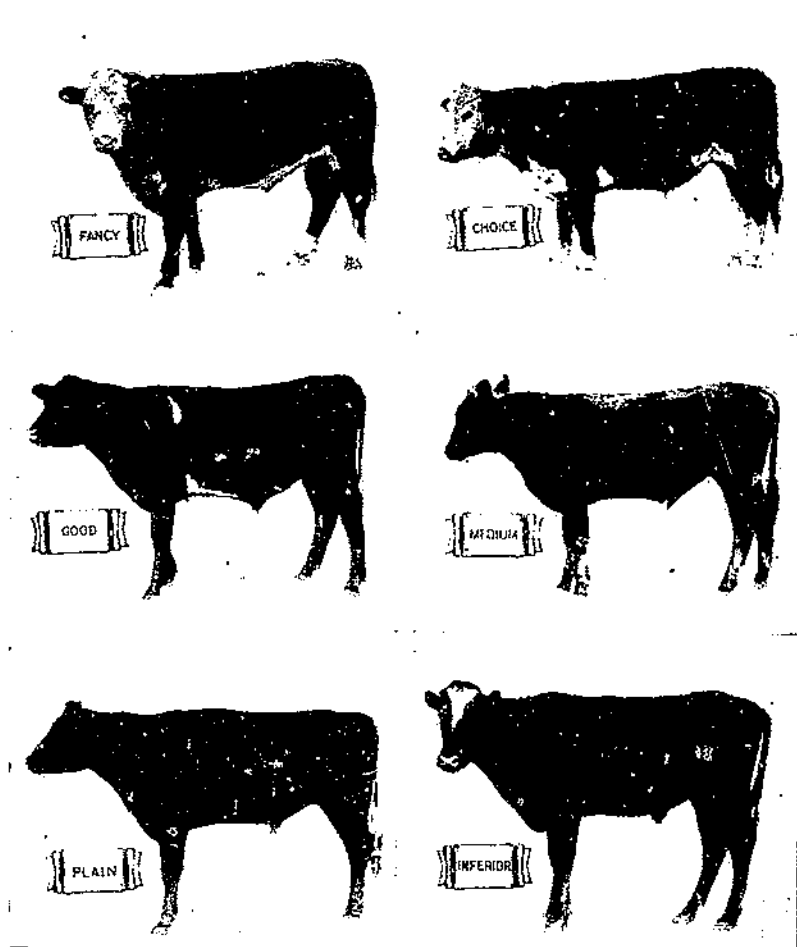


FIGURE 1.—United States grades of feeder steers.

RESULTS FROM STEER CALVES

Of the 914 steer calves used, 69 were designated by the grading committee as Fancy in feeder grade, 592 as Choice, 227 as Good, and 26 as Medium. Subgrades of feeders are not considered in the four sections of this report which deal separately with steer calves, yearling steers, 2-year-old steers, and heifer calves, but were considered in the section dealing with the correlation study of the data on all cattle as one group.

Considerable variation existed within each of the grades of steer calves with respect to initial weight and rate of gain, as well as total gain and final weight. To determine the relation of variations in

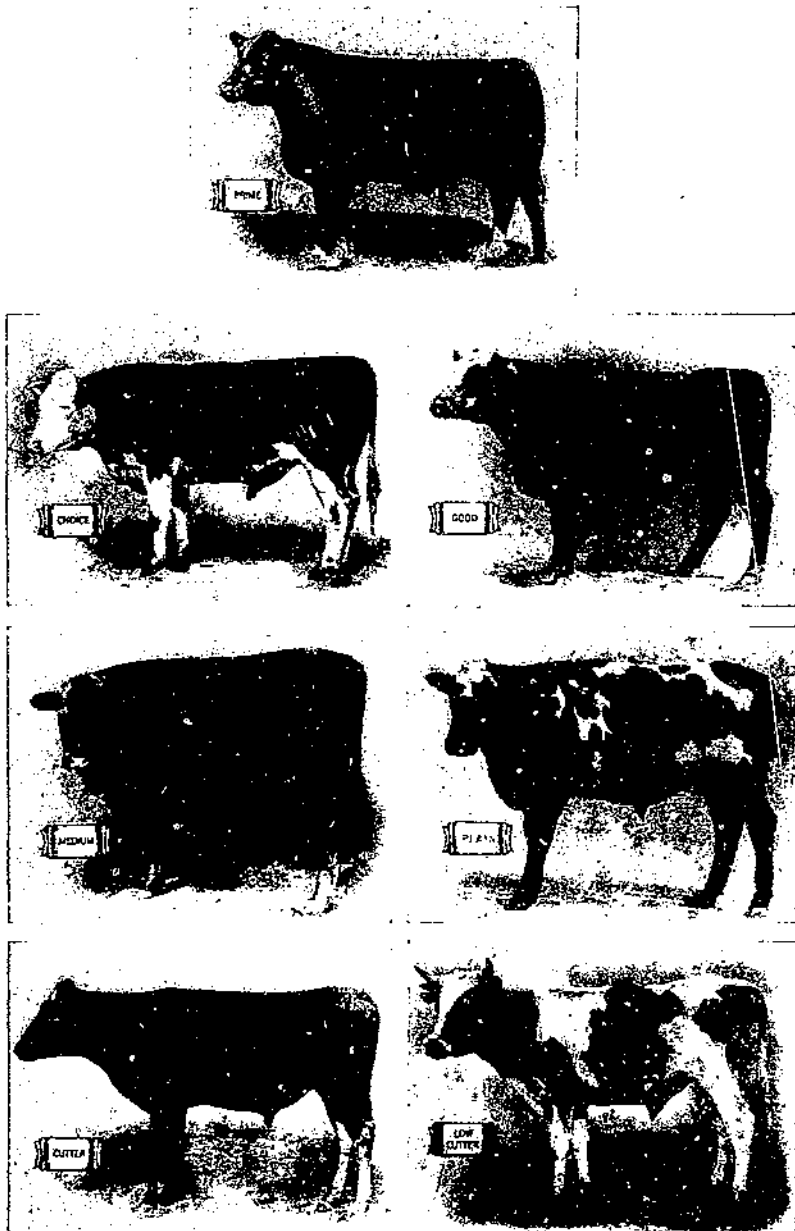


FIGURE 2.—United States grades of slaughter steers.

initial weight and rate of gain to carcass grade, when total gains were equal, an arbitrary division was made of the cattle of each feeder grade. Those with initial weights of 400 pounds or more

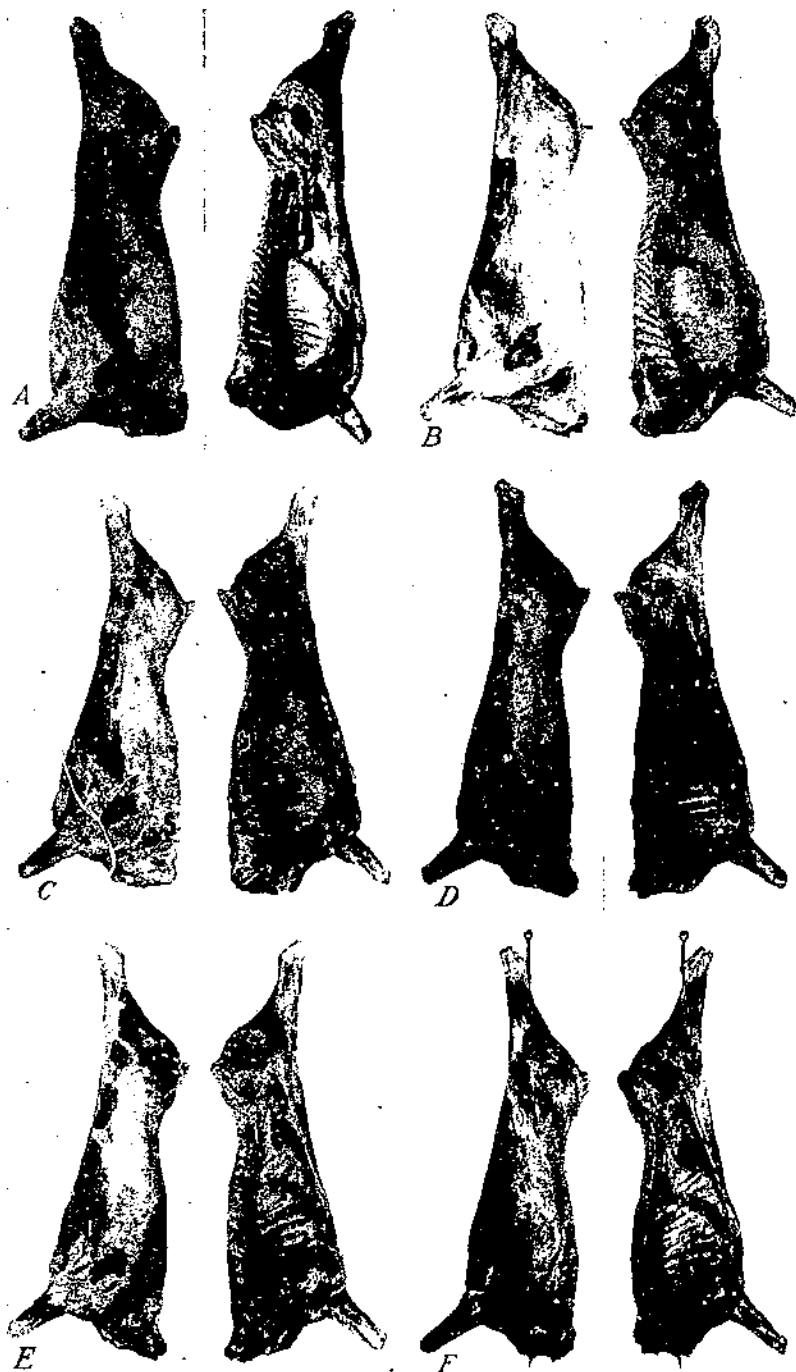


FIGURE 3.—United States grades of steer carcasses: *A*, Prime; *B*, Choice; *C*, Good; *D*, Medium; *E*, Plain; *F*, Cutler. (Satisfactory illustration of Low Cutler not available.)

were considered as one group and those with weights of less than 400 pounds as another group. Within each of these groups a division was then made on the basis of rate of gain. The cattle which gained

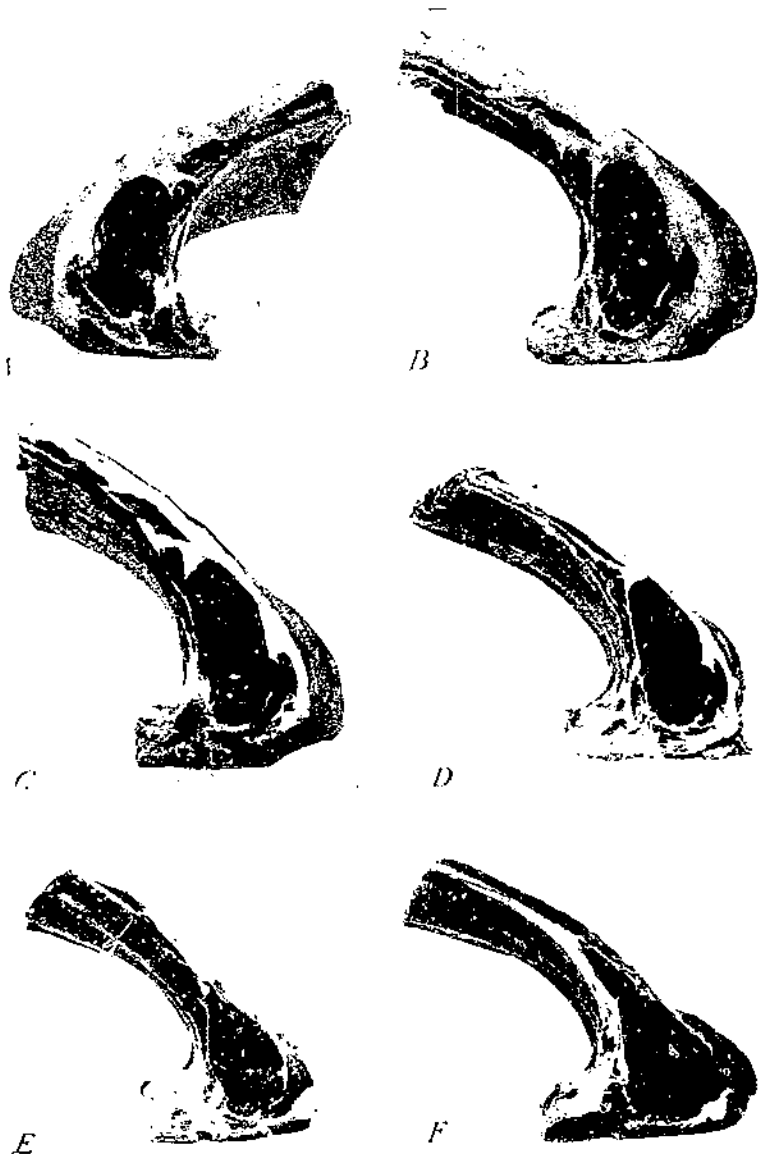


FIGURE 1.—United States grades of rib cuts from steer carcasses: *A*, Prime; *B*, Choice; *C*, Good; *D*, Medium; *E*, Plain; *F*, Cutter. (Satisfactory illustration of Low Cutter rib not available.)

an average of 2 pounds or more daily were considered as one group and those which gained less than 2 pounds daily as the other group. The data obtained from these divisions are shown in table 1.

TABLE 1.—Average initial weights and gains per day of groups of Fancy, Choice, Good, and Medium feeder-steer calves

Initial weight (pounds)	Feeder grade	Cattle	Average initial weight	Average daily gain			
				Cattle gaining 2 pounds or more daily		Cattle gaining less than 2 pounds daily	
		Number	Pounds	Number	Pounds	Number	Pounds
400 or more	Fancy	51	524.6	33	2.22	18	1.76
	Choice	261	457.9	185	2.27	76	1.74
	Good	166	453.7	45	2.20	61	1.63
	Medium	23	484.4	7	2.11	16	1.48
Less than 400	Fancy	18	392.2	4	2.07	14	1.85
	Choice	331	351.4	176	2.22	155	1.66
	Good	121	331.2	73	2.23	48	1.62
	Medium	3	380.7	1	2.23	2	1.88

Each of the four resulting groups in each feeder grade was then subdivided according to total gain made during the feeding period. The ranges of gains employed in making these subdivisions were as

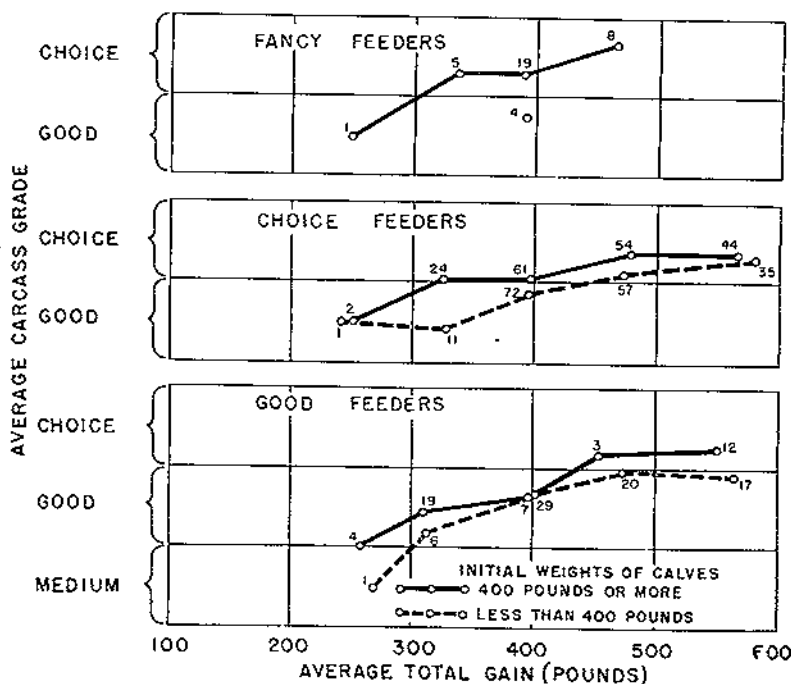


FIGURE 5.—Carcass grades of steer calves as influenced by initial weights and total feedlot gains. Calves gaining 2 pounds or more per head daily are represented.

follows: Up to 200 pounds, 200 to 279 pounds, 280 to 359 pounds, 360 to 439 pounds, 440 to 519 pounds, 520 pounds and more. The average total gains and major carcass grades were then determined for each of these subdivisions.

INITIAL WEIGHT IN RELATION TO CARCASS GRADE WITH TOTAL GAINS EQUAL

Figures 5, 6, and 7 show the relation of differences in initial weight to carcass grade, based on the groupings of cattle previously mentioned. The Medium feeder cattle are disregarded in these figures on account of the very small number of individuals weighing less than 400 pounds when the experiment was begun. Figure 5 deals with the steer calves that gained at the rate of 2 pounds or

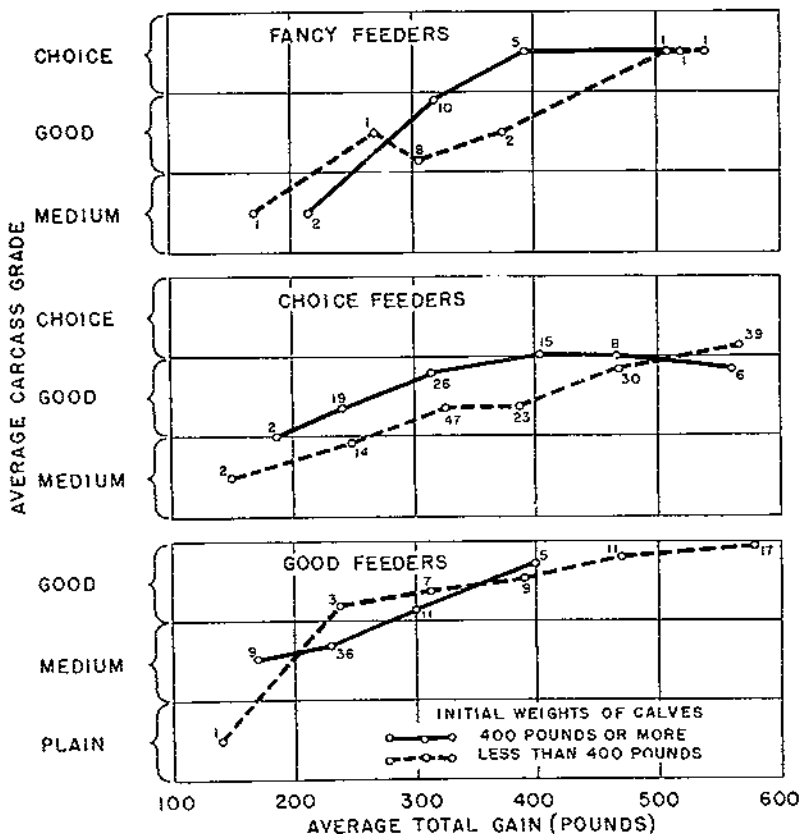


FIGURE 6.—Carcass grades of steer calves as influenced by their initial weights and total feed-lot gains. Calves gaining less than 2 pounds per head daily are represented.

more per day, figure 6 with the calves which gained less rapidly, and figure 7 with all the calves in the two weight groups, without taking into account differences in rate of gain. In these figures, as well as in succeeding ones, numbers on the curves represent the number of animals at the various points of gain.

For the Choice feeder calves, figures 5, 6, and 7 show a definite relation between initial weight and carcass grade, when total gains were equal. It is apparent that with this grade of feeders higher carcass grade was produced by the calves with the heavy initial weights. The same relation is indicated for the Fancy feeders. The curves for Choice and Fancy calves, especially the former, involv-

ing larger numbers, also show that as total gains became very large there was a tendency for the differences between carcass grades of the two weight groups of feeders to become increasingly smaller.

The Good feeders with initial weights of 400 pounds or more and making rapid gains (fig. 5) produced, in general, higher grading

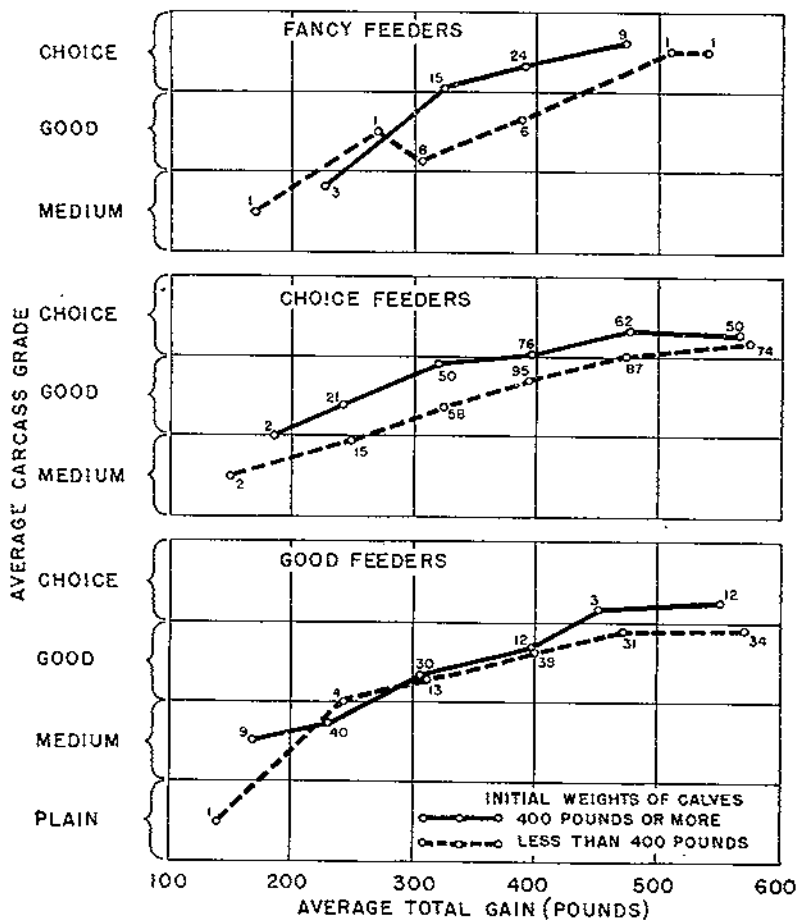


FIGURE 7.—Carcass grades of all the experimental steer calves as influenced by their initial weights and total feed-lot gains.

carcasses than did those with lower weight. With the slower gaining calves (fig. 6) there was considerable overlapping of the two curves. Figure 7 shows, however, that after a gain in weight of about 400 pounds the heavy Good feeders on the whole tended to produce slightly higher grading carcasses. It appears, in general, that as feeder grade increased from Good to Fancy there was a tendency for a difference in initial weight within the grade to have more and more effect on carcass grade.

RATE OF GAIN IN RELATION TO CARCASS GRADE WITH TOTAL GAINS EQUAL

The range in rate of gain among the 914 steer calves was from 0.7 to 2.9 pounds per day.

Figures 8 and 9 show the relation of rate of gain to carcass grade. The former deals with calves of initial weights of 400 pounds or more, the latter with calves weighing less than 400 pounds. In

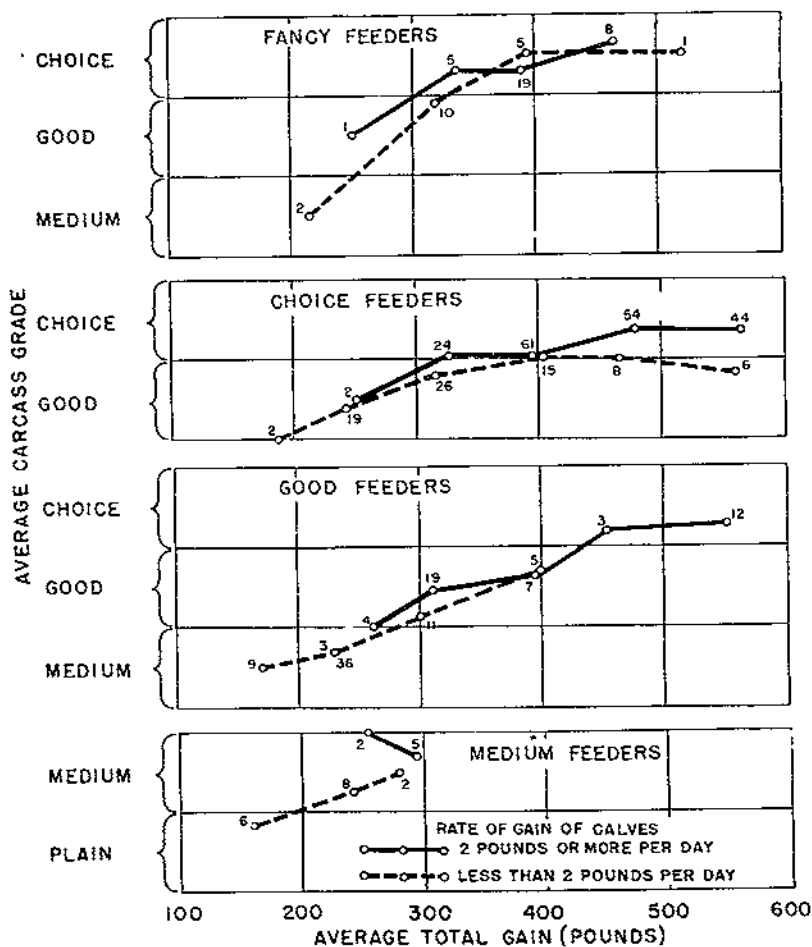


FIGURE 8.—Carcass grades of steer calves as influenced by their rates of gain and total gains in the feed lot. Calves having initial weights of 400 pounds or more are represented.

each feeder grade the calves gaining an average of 2 pounds or more per day are compared with those gaining less than 2 pounds daily.

The differences in carcass grade shown in figures 8 and 9 are small, on the whole. In fact, with the Fancy feeders the results indicate no significant difference between the rapid- and slow-gaining cattle. No definite conclusion in this respect seems justified, however, in view of the limited data. The difference in carcass grade shown at the right-hand extreme of the curves for Choice steers in figure 8

probably would not be so large, under strictly normal conditions, as it appears here. The decline in carcass grade of the slower gaining cattle, after a gain of about 400 pounds, seems abnormal. One is led to believe that at least the six cattle whose carcass grades are shown at the final point of the curve as an average were subnormal. From a consideration of both figures 8 and 9 it may be concluded that, in general, except for the Fancy feeders, there was a tendency for slightly higher grading carcasses to result from the more rapid gains in the feed lot, when equal total gains were made.

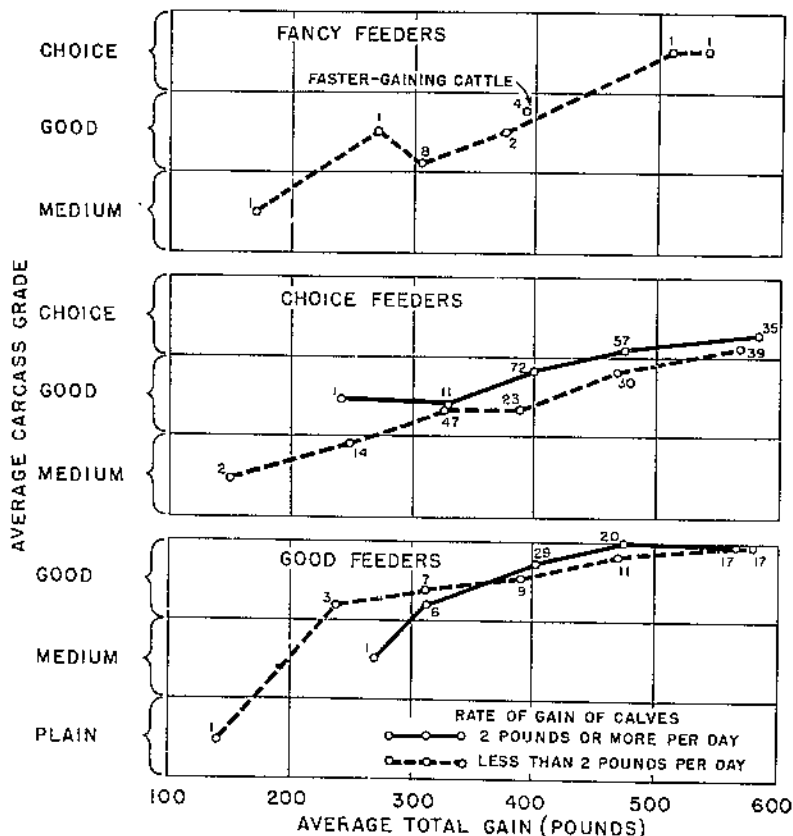


FIGURE 9.—Carcass grades of steer calves as influenced by their rates of gain and total gains in the feed lot. Calves having initial weights of less than 400 pounds are represented.

Brief consideration is given at this point to the combined influence of initial weight and rate of gain on carcass grade. Figure 10, dealing with Choice feeder steer calves as an example, shows the differences between the carcass grades of the calves with the heavier initial weights (400 pounds or more) and making the faster gains (2 pounds or more per day) and the carcass grades of the calves which weighed less than 400 pounds and gained less than 2 pounds per day. At equal total gains there was a distinct difference in favor of the heavier, faster gaining feeders. The maximum difference was two-thirds of a grade. As total gain increased the difference between the carcass

grades of the two weight groups decreased. The difference was less than one-third of a grade after a gain of 535 pounds had been made. Assuming a smoothing of the curve for the heavier, faster gaining calves, it will be observed that they reached Choice grade in carcass with approximately 175 pounds less total gain than the lighter, slower gaining calves. Obviously, if it is desired to market higher grading cattle without increasing the total feed-lot gain, when Choice feeder steer calves are used, there is a distinct advantage in obtaining heavier feeders and feeding a ration that will promote rapid gains.

FEEDER GRADE AND TOTAL GAIN IN RELATION TO CARCASS GRADE

Figure 11 shows the relation of feeder grade and total gain to carcass grade of the calves with initial weights of 400 pounds or more and of those with weights of less than 400 pounds. In general, the cattle of the different feeder grades of both weight groups varied considerably in total gain. This was particularly true of the Fancy, Choice, and Good grades. The heavyweight Fancy calves ranged

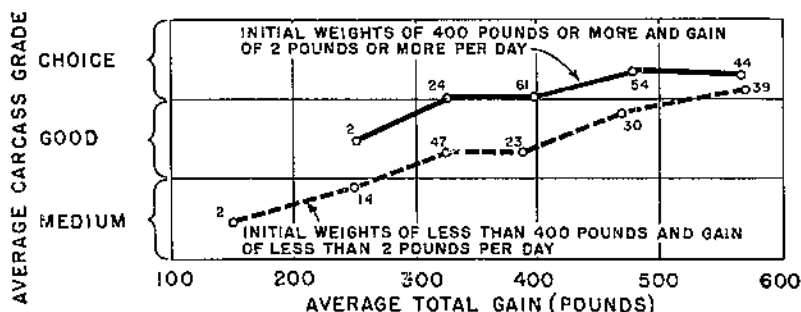


Figure 10.—Carcass grades of steer calves as influenced by their initial weights and rates of gain and total gains in the feed lot. Both groups of calves represented were of Choice feeder grade.

from 227 to 471 pounds in average total gains, the Choice calves from 185 to 566 pounds, and the Good calves from 170 to 551 pounds, but the Medium calves only from 160 to 290 pounds. The lightweight Fancy calves ranged from 170 to 540 pounds in average total gains, Choice calves from 150 to 574 pounds, Good calves from 140 to 572 pounds, and Medium calves only from 245 to 290 pounds. All feeder grades represented were relatively low in carcass grade when total gains were small. However, marked increases in carcass grade occurred with increasing gains in the feed lot.

Figure 11 shows further that the Fancy steer calves with the higher initial weights, after gaining about 325 pounds, produced low Choice carcasses and, after a gain of about 400 pounds, average Choice carcasses. Choice feeders of the same weight group, after making a gain of about 240 pounds, produced average Good carcasses. With gains of about 280 and 380 pounds they produced high Good and low Choice carcasses, respectively. Good feeders showed an increase in carcass grade from average Medium to low Choice. This change in grade accompanied the increase in gain of 170 to 551 pounds. Similar relationships are shown in the other groups, thus illustrating the marked influence of total gain on carcass grade.

Figure 11 shows many instances in which the carcass grade was distinctly higher or lower than the feeder grade of the same animal. This result may have been due in part to the differences that exist in the standards between feeder cattle and slaughter cattle or carcass grades. The characteristics of the higher grades of feeder cattle, in particular, are distinctly different from those of the corresponding grades of slaughter cattle; therefore if Choice or Fancy feeders are slaughtered their carcasses are similar to those of slaughter cattle grading approximately two grades lower. For this reason more improvement is necessary with the Choice and Fancy feeders in order

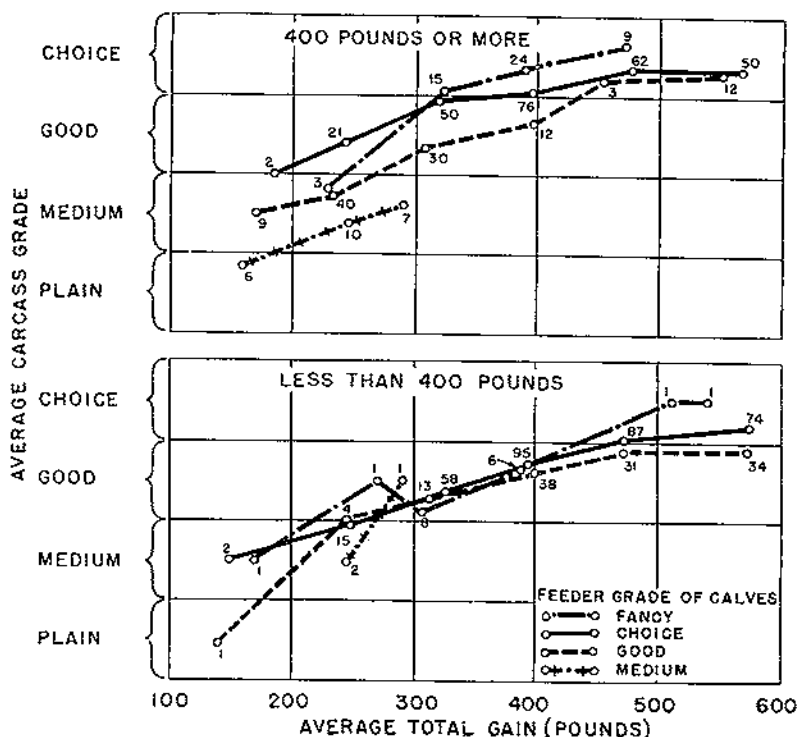


FIGURE 11.—Carcass grades of steer calves, with initial weights of 400 pounds or more and of less than 400 pounds, as influenced by their feeder grades and total feed-lot gains.

that they grade Choice and Prime, respectively, in the carcass than is required, for example, for Medium feeders to grade Medium in the carcass. The required improvement is associated with total gain during the fattening period. In this connection, it may be noted that in the heavier group Medium feeders produced Medium carcasses after a total gain of approximately 185 pounds, Good feeders produced Good carcasses at 270 pounds, and Choice feeders Choice carcasses at 380 pounds of gain. The heavy Fancy feeders failed to produce Prime carcasses at a gain of 470 pounds.

The total gain required by different grades of feeders to produce a uniform grade of carcass is a matter of distinct interest and importance. Assuming a slight smoothing of the curves in figure 11,

these heavyweight Fancy, Choice, and Good steer calves produced Choice carcasses, for example, after gaining approximately 310, 380, and 460 pounds, respectively. The relatively greater difference between the initial weights of the light and heavy calves of the Fancy grade than of the other grades (as shown by table 1) may have been responsible in part for the production of Choice carcasses after only 310 pounds of gain. Nevertheless, in view of the clear-cut comparative results from the Choice and Good feeders, the requirement of less gain by the higher grade calves seems definitely established.

Another important result shown in figure 11 is the relatively small spread in average carcass grades at any given point of gain. By assuming a slight projection of the curves for Medium feeders in the heavyweight group, it is possible to compare the average carcass grades of the four grades of feeder cattle when each had made a gain of 325 pounds. This comparison shows a range of about 1.2 grades, representing the difference between the average carcass grades of the cattle which were Fancy and Medium grade as feeders. At 400 pounds of gain Fancy, Choice, and Good feeders show a range in carcass grade of about 0.7 of a grade. These three grades of feeders continued to show about this same range in carcass grade at 465 pounds of gain.

A further study of figure 11 shows that the somewhat narrow range in carcass grades, mentioned in the foregoing paragraph, is caused by a greater difference in grade between the higher grading feeders and their respective carcasses than between the lower grading feeders and their carcasses. To illustrate: According to these results, if a typical Choice feeder-steer calf weighing about 450 pounds is slaughtered after a gain of about 200 pounds in the feed lot, the carcass will be only low Good in grade, or approximately 1.4 grades lower than the individual was as a feeder. Under similar conditions the Good and Medium feeder calves show a decline of about 0.9 and 0.4 of a grade, respectively, between feeder and carcass. It is estimated that the carcass of the Fancy feeder which has made a gain of 200 pounds would be approximately average Good in grade, the difference between feeder and carcass being about two grades. With greater total gains these differences would be much reduced. Obviously, if advantage is to be taken of the potential ability of the higher grading, more costly feeders to produce high-grade carcasses, they must be fed for at least moderately large gains. Stated another way, it seems unwise to pay the extra price usually necessary to obtain Fancy feeders unless they are to be well finished before being marketed. In this connection it should be noted that, with the more extreme gains, the Fancy feeders showed a distinct ability to produce carcasses of the highest grade. These results are in accord with the experience of many cattlemen. The characteristics of low-grade feeders are such that even when the animals are fed for a long period and are well finished, they yield carcasses that are usually deficient in other respects and not comparable with the high-grading carcasses.

In the lightweight calves of the four different feeder grades, the most striking feature shown in figure 11 is the small difference in

the carcass grades before about 450 pounds of gain was made. After a gain of 450 pounds there was a greater spread in the curves.

INITIAL WEIGHT IN RELATION TO CARCASS GRADE WITH FINAL WEIGHTS EQUAL

As a final step in the analysis of data on steer calves, the relation of variation in initial weight to carcass grade was determined when final weights were equal.

Figure 12 shows the relationship between final weight and carcass grade for the two groups of calves in each grade, divided according to initial weight. The average difference in total gain at any point of final weight is equal to the difference between the aver-

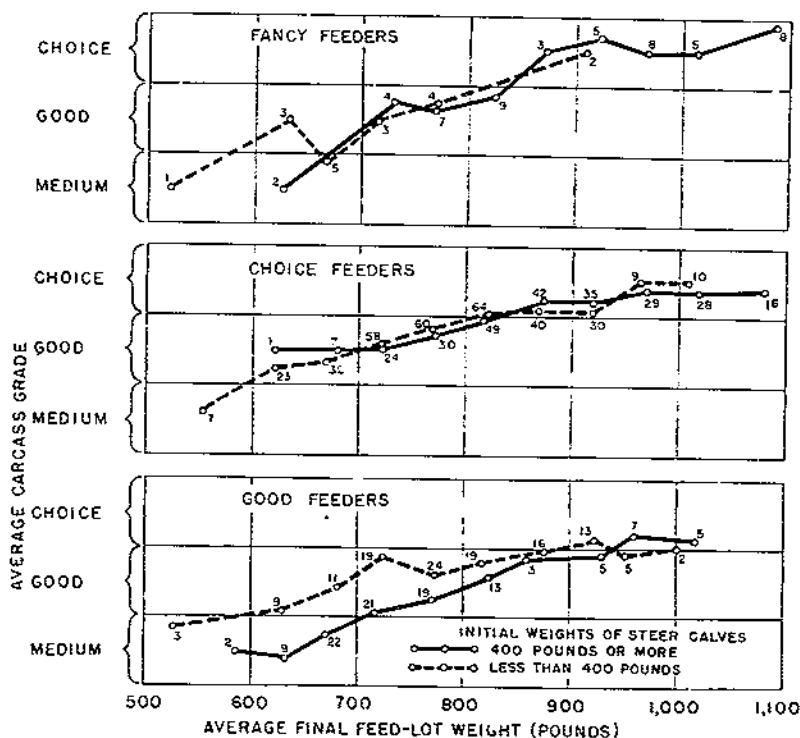


FIGURE 12.—Carcass grades of steer calves as influenced by their initial and final feed-lot weights.

age initial weights of the two groups of calves, with the lightweight calves making the greater gain. For the Fancy, Choice, and Good feeders, the average differences in initial weights between the two groups were 163, 107, and 117 pounds, respectively (table 1).

In the Fancy and Choice feeders, a distinct difference in initial weight failed to reflect significant differences in carcass grades, when the animals in each of these two feeder grades were fed to equal final weights. The Good feeders, however, showed quite different results. At the lower final weights a distinct difference in carcass grades was associated with the difference in initial weights, the lightweight calves producing the higher grading carcasses. The spread in carcass grades gradually became less as final weight increased.

At final weights exceeding approximately 800 pounds the differences became so small and irregular as to have little significance.

RESULTS FROM YEARLING STEERS

The data on 331 yearling steers were analyzed in the same manner as those on the steer calves. Of the total number of feeder yearlings, 60 were graded Choice, 118 Good, 132 Medium, and 21 Plain. For analysis of the data the cattle in each feeder grade were divided into two groups with respect to initial weight. The cattle weighing 650 pounds or more were included in one group and those weighing less than 650 pounds in the other. Each group was then subdivided with respect to rate of gain. The individuals which gained at an average rate of 1.8 pounds or more daily were included in one subgroup and those which gained less than 1.8 pounds daily in the other. Table 2 shows the average initial weights and gains per day for the several groups.

TABLE 2.—Average initial weights and gains per day for groups of Choice, Good, Medium, and Plain yearling feeder steers

Initial weight (pounds)	Feeder grade	Cattle	Average initial weight	Average gain per day			
				Cattle gaining 1.8 pounds or more daily		Cattle gaining less than 1.8 pounds daily	
		Number	Pounds	Number	Pounds	Number	Pounds
650 or more	Choice	38	758.2	21	2.23	11	1.53
	Good	57	731.8	26	2.22	29	1.41
	Medium	66	721.7	24	1.95	42	1.45
	Plain	4	712.5	2	1.96	2	1.47
Less than 650	Choice	22	605.0	20	2.20	2	1.37
	Good	63	558.0	39	2.05	21	1.42
	Medium	66	588.5	26	1.97	40	1.37
	Plain	17	520.6	5	1.98	12	1.41

INITIAL WEIGHT AND RATE OF GAIN IN RELATION TO CARCASS GRADE WITH TOTAL GAINS EQUAL

The data were analyzed to determine the relation of initial weight to carcass grade. Consideration was given in this respect to both the rapid-gaining cattle (those gaining 1.8 pounds or more per day) and the slow-gaining cattle (those gaining less than 1.8 pounds per day). In general the heavier feeder yearlings produced slightly higher carcass grades than did the lighter feeders when total gains were equal. This result is in accord with that obtained with steer calves. However, limited data made it impossible to determine whether, as feeder grade increased, a difference in initial weight tended to become more significant in relation to carcass grade.

Analysis of the data was also made to determine the relation between rate of gain and carcass grade. Both weight groups of cattle of each feeder grade were considered. As shown especially by the Good and Medium feeders, of which there were the largest numbers, more rapid gains resulted in the production of slightly higher grading carcasses, when total gains were equal. This result, likewise, is in general accord with that obtained with steer calves. Because of these similarities in results it is not considered necessary to

present figures showing the relationships of initial weight and rate of gain to carcass grade for the yearling steers.

FEEDER GRADE AND TOTAL GAIN IN RELATION TO CARCASS GRADE

Figure 13 shows the relationship of feeder grade and total gain to carcass grade for the two weight groups of cattle. The heavy Choice feeders produced Choice carcasses after a gain of approximately 390 pounds, Good feeders produced Good carcasses after a gain of about 285 pounds, and Medium carcasses apparently would have been produced by the Medium feeders even before they had made 175 pounds of gain. Comparison of the light with the heavy

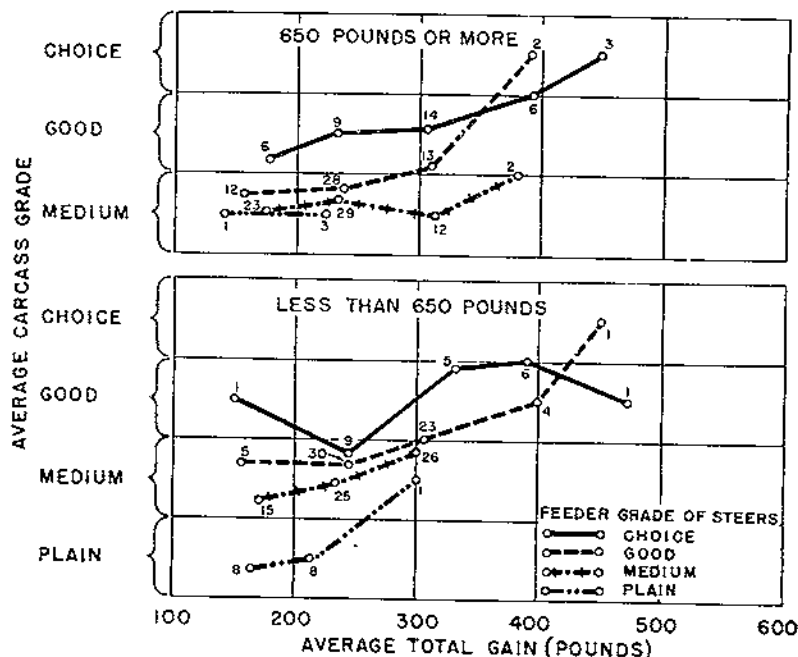


FIGURE 13.—Carcass grades of yearling steers, with initial weights of 650 pounds or more and of less than 650 pounds, as influenced by their feeder grades and total feed-lot gains.

Choice feeders shows that the gain required to produce Choice carcasses was the same. In the light and heavy Medium feeders, the same gain also was required to produce Medium carcasses. There was little difference between the two groups of Good feeders, although the gain requirement of the lightweight group was slightly larger. The lightweight Plain feeders appeared to require less than 150 pounds of gain to produce Plain carcasses.

The heavy Choice feeders reached the midpoint of the Good grade, with respect to carcass, with a gain of approximately 250 pounds and the Good feeders with a gain of about 350 pounds. The light Choice feeders produced carcasses grading average Good with a gain of about 300 pounds, and Good feeders of similar weight required slightly less than 400 pounds of gain to accomplish the same result. In other words, the light feeders of each grade required approxi-

mately 50 pounds greater gain than the heavy steers to produce average Good carcasses.

The somewhat narrow range in carcass grade shown by the curves for Choice, Good, and Medium feeders at any point of gain in figure 13 is also of interest. Although a spread of two full grades occurred in the feeder cattle, the maximum spread in carcass grade as shown by the two sets of three curves is considerably less than two grades. This fact was due to a greater difference in grade, between feeder and carcass, with the higher (Fancy and Choice) than with the lower grading feeders when small gains were made. These results indicate that higher grading feeder yearling steers, as well as steer calves, must be fed for at least moderately large total gains on the finishing ration if high-grading carcasses are to be produced.

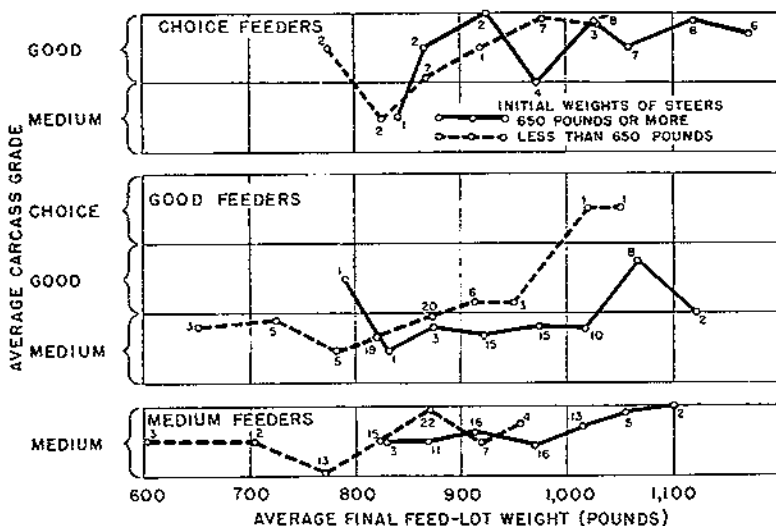


FIGURE 14.—Carcass grades of yearling steers as influenced by their initial and final feed-lot weights.

INITIAL WEIGHT IN RELATION TO CARCASS GRADE WITH FINAL WEIGHTS EQUAL

The possible relation to carcass grade of a difference in weight at the beginning of the feeding period, when final weight was constant, was considered in the analysis of the data on yearling steers. Three feeder grades, Choice, Good, and Medium, were represented by sufficient numbers to justify such consideration. Figure 14 shows the results of this phase of the study.

In the Choice grade there was a difference of 153 pounds between the average initial weights of the light and heavy steers, as shown by table 2. Therefore at any time during the fattening period, when the average final weights of the two groups were the same the lighter cattle had gained 153 pounds more than the heavier cattle. Although there is considerable irregularity in the curve representing the heavier cattle, the results indicate that the lighter feeders tended to produce somewhat higher grading carcasses at equal final weights.

The two weight groups of Good feeders had a difference of 166 pounds in average initial weight. Figure 14 clearly shows that the lighter feeders produced slightly higher grading carcasses when both groups were fed to the same final weight. The data permit comparisons to be made throughout a range in final weight of from approximately 825 to 1,000 pounds.

The average initial weights of the two groups of Medium steers were 722 and 589 pounds, the difference being 133 pounds. The lighter feeders again tended to produce the higher grading carcasses at equal final weights. However, the data are somewhat limited and the curve for the lighter feeders irregular. The comparison, therefore, can be made only within a narrow range of final weight centering at about 900 pounds. It may be concluded from these results that in general the lighter yearling steers, making the correspondingly greater gains in the feed lot, produced slightly higher grading carcasses than the heavier steers of equal feeder grade.

RESULTS FROM 2-YEAR-OLD STEERS

Records on 349 2-year-old steers were available for analysis. In feeder grade 51 of these were classed as Choice, 154 Good, and 144 Medium. As with the classes of cattle previously considered, groupings were made with respect to initial weight and rate of gain. The dividing points employed in each feeder grade were 850 pounds in initial weight and 2 pounds in rate of gain. Table 3 shows the average initial weights and gains per day for the groups of Choice, Good, and Medium feeder steers.

TABLE 3.—Average initial weights and gains per day for groups of Choice, Good, and Medium 2-year-old feeder steers

Initial weight (pounds)	Feeder grade	Cattle	Average initial weight	Average gain per day			
				Cattle gaining 2 pounds or more daily		Cattle gaining less than 2 pounds daily	
		Number	Pounds	Number	Pounds	Number	Pounds
550 or more	Choice	33	1,007.1	20	2.27	13	1.33
	Good	92	911.1	65	2.51	27	1.42
	Medium	45	994.2	37	2.52	8	1.71
Less than 850	Choice	16	781.1	12	2.42	4	1.45
	Good	62	793.5	33	2.17	29	1.42
	Medium	99	716.4	69	2.11	30	1.40

INITIAL WEIGHT AND RATE OF GAIN IN RELATION TO CARCASS GRADE WITH TOTAL GAINS EQUAL

The data for the 2-year-old steers were analyzed to determine the relation of initial weight to carcass grade. In this particular comparison differences in rate of gain were disregarded. The results showed that, in general, the heavy Choice feeders produced distinctly higher grading carcasses than the light Choice feeders when equal total gains were made on the finishing ration. The difference between the average initial weights was 223 pounds, as shown by table 3. With the Good and Medium feeders the differences in initial weights between the heavy and light groups—178 pounds and 188

pounds, respectively—did not appear to have an influence on carcass grade.

In general the slower gaining cattle among the 2-year-old steers were fed for rather small total gains and the faster gaining cattle for relatively large total gains. It was possible, therefore, to make direct comparisons of carcass grades, with total gains equal, at only a few stages of total gain. Careful analysis of the data suggested, however, that a difference in rate of gain had little bearing, if any, on carcass grade.

FEEDER GRADE AND TOTAL GAIN IN RELATION TO CARCASS GRADE

Figure 15 shows the relationships of feeder grade and total gain to carcass grade for the two groups of 2-year-old cattle divided ac-

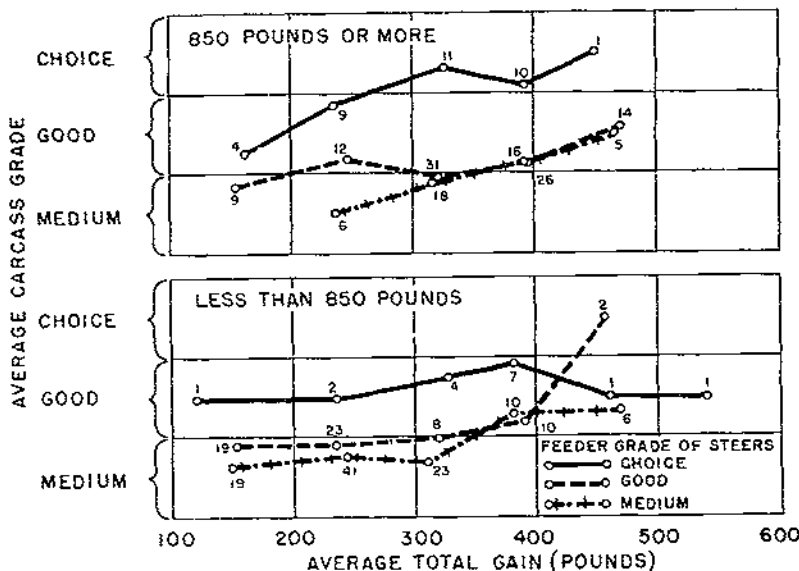


FIGURE 15.—Carcass grades of 2-year-old steers, with initial weights of 850 pounds or more and of less than 850 pounds, as influenced by their feeder grades and total feed-lot gains.

ording to initial weight. Choice feeders of the heavy group with a gain of about 290 pounds produced Choice carcasses. A slight decline in carcass grade of the Good feeders is shown between 244 pounds and 320 pounds of gain, but it appears from a smoothing of the curve that such feeders normally would produce Good carcasses after a gain of about 290 pounds. Of particular interest is the fact that the curves for the Good and Medium heavy feeders come together at about 375 pounds of gain and practically coincide from that point to the end, or until a gain of about 475 pounds is made.

Figure 15, dealing also with the lightweight group of 2-year-old cattle, indicates that about 400 pounds of gain would have been required in the average case by the Choice feeders to produce Choice carcasses. The Good feeders produced Good carcasses after making a gain of about 320 pounds. The Medium feeders produced Medium carcasses up to approximately 350 pounds of gain, after which they

produced Good carcasses. The curves representing the Good and Medium feeders tend to come together at 350 to 400 pounds of gain. The same trend was noted with the heavier cattle, as stated previously.

A somewhat narrow range in carcass grade is shown, as with steer calves and yearling steers. This is true for the several grades of 2-year-old feeder steers in figure 15 at any given point of gain. This result was slightly more pronounced with the cattle that weighed less than 850 pounds at the beginning of the feeding period than with those that weighed 850 pounds or more as feeders. As in former instances, this narrowness of range in carcass grade was due to greater difference in grade, from feeder to carcass, by the higher grading than by the lower grading feeders, at the stages of small gains.

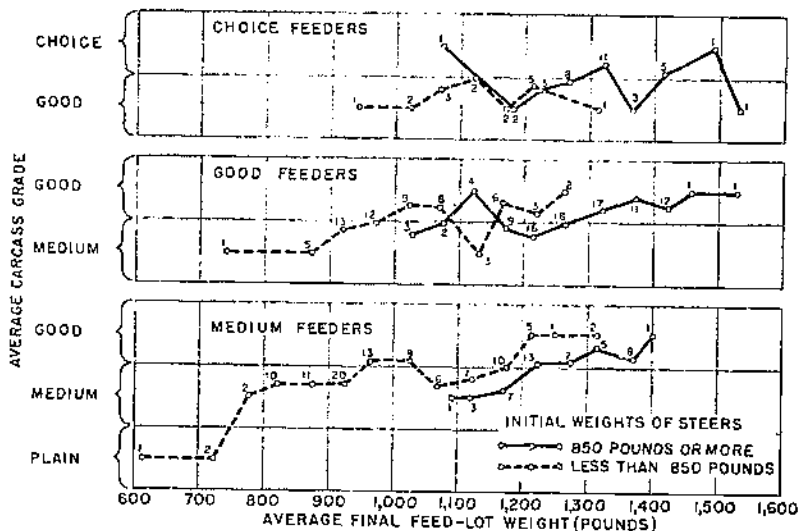


FIGURE 16.--Carcass grades of 2-year-old steers as influenced by their initial and final feed-lot weights.

INITIAL WEIGHT IN RELATION TO CARCASS GRADE WITH FINAL WEIGHTS EQUAL

The possible relation to carcass grade of a difference in initial weight within the feeder grade, when final weight was constant, was considered in the analysis of data on 2-year-old steers. As previously noted, the differences between the average initial weights of the heavier and lighter groups of feeders were 223, 178, and 188 pounds for the Choice, Good, and Medium grades, respectively. Figure 16 shows the results from these three grades of feeders.

With the Choice feeders no distinct difference in carcass grade can be noted. However, small numbers of individuals are represented at the points on the curves where direct comparisons can be made, and considerable irregularity exists in the curves. Therefore, it is impossible to make definite conclusions. Similar consideration of steer calves showed no differences either with Choice or Fancy feeders. However, with Choice, Good, and Medium yearling steers the lighter animals produced somewhat higher grading carcasses.

The Good 2-year-old feeders of the lighter initial-weight group produced, in general, the higher grading carcasses at equal final weights ranging from approximately 1,025 to 1,265 pounds. Except for one irregularity, in which the curves cross and recross, the differences in carcass grade did not exceed one-half grade at any point.

With the Medium feeders, likewise, total gain was more important than higher initial weight when final weight was constant.

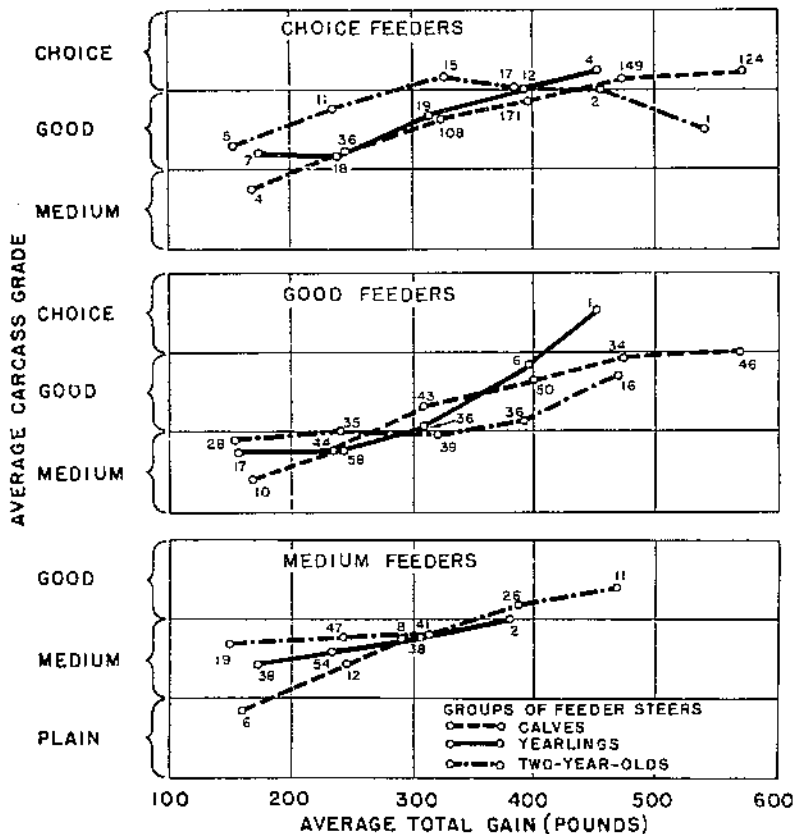


FIGURE 17.—Carcass grades of steers as influenced by their ages and total feed-lot gains.

The lighter weight feeders yielded the higher grading carcasses at equal final weights ranging from approximately 1,100 to 1,300 pounds. Again the difference in carcass grade did not exceed one-half grade.

COMPARISON OF STEER CALVES, YEARLING AND 2-YEAR-OLD STEENS

In the data already presented on steer calves, yearling and 2-year-old steers, variations in initial weight and rate of gain were shown to be somewhat minor factors with respect to influence on carcass grade. On the other hand, feeder grade and total gain showed strong evidence of being relatively important factors. In

the following comparisons of steers of the three different ages, attention is given only to feeder grade and total gain in relation to carcass grade. The only divisions made of any group of steers—Choice feeder steer calves, for example—are those pertaining to total gain.

Data are available to permit age comparisons to be made in the Choice, Good, and Medium grades of feeders. As before, the ranges employed in making the groupings with respect to total gain were as follows: Less than 200 pounds, 200 to 279 pounds, 280 to 359 pounds, 360 to 439 pounds, 440 to 519 pounds, 520 pounds and more. Table 4 shows the number of steers of each age in each feeder grade and the corresponding average initial weights and gains per day, and figure 17 shows the comparative results obtained.

TABLE 4.--Average initial weights and gains per day of steer calves, yearling and 2-year-old steers of different feeder grades

Feeder grade	Age group	Steers used		Gain per day
		Number	Initial weight Pounds	
Choice	Calves	792	308.3	2.01
	Yearlings	60	702.0	2.03
	2-year-olds	51	937.3	1.96
Good	Calves	227	391.6	1.94
	Yearlings	118	415.3	1.77
	2-year-olds	151	863.6	2.13
Medium	Calves	26	169.6	1.69
	Yearlings	132	655.1	1.61
	2-year-olds	144	775.1	2.22

Figure 17 shows that among the Choice feeders the 2-year-old cattle, in general, produced the highest grading carcasses with the calves the lowest, at stages of equal gains. However, the difference between the two curves representing calves and yearlings is small. The results suggest that the normal curve for Choice 2-year-old feeders would pass through a point about midway between the two points representing 15 and 17 individuals and cross the line between Good and Choice carcasses at the stage of approximately 325 pounds of gain. The curves representing yearlings and calves cross this line at about 390 and 440 pounds of gain, respectively.

There is marked overlapping of the curves for the Good feeders shown in figure 17. The small increase in carcass grade by the 2-year-old steers between approximately 235 and 390 pounds of gain is particularly noticeable, and the more rapid increase in grade from 390 to 470 pounds justifies a question as to whether it is normal for such steers to make such large weight gains with so little improvement in grade. In general a more rapid increase in carcass grade is indicated for both the calves and yearlings. It is apparent that there was no consistent relation between age and carcass grade among these Good feeders at the various points of equal gain.

With Medium feeders there was a direct relation between age of feeder and carcass grade, up to a gain of 290 pounds. That is, with equal total gains the 2-year-old cattle produced the highest grading carcasses and the calves the lowest. Although the calves produced the lowest grading carcasses, they increased in carcass grade up to 290 pounds of gain more rapidly than did the yearlings and 2-year-olds. This same result, in general, was obtained with the Good

cattle. The Medium feeders, at gains in excess of about 240 pounds, showed a range in average carcass grade of less than one-third of a grade. The maximum range, appearing at about 160 pounds of gain, was approximately three-fourths of a grade.

The results in figure 17 show that, in general, there was a tendency for the older steers to produce higher grading carcasses than the younger steers, when total gains were equal. This result is indicated most clearly by the set of curves for Choice feeders. This tendency is not difficult to understand when it is considered that with the older cattle a larger proportion of the gain is in the form of finish, which contributes so greatly to carcass grade. However, the differences in carcass grade associated with variation in age within the feeder grade were not large, and except among the Choice feeders, age is not regarded as having exerted an important influence on carcass grade when total gain was constant.

RESULTS FROM HEIFER CALVES

Data on 270 heifer calves were considered in this analysis. Of these calves, 167 were classed as Choice feeders and 103 as Good feeders. Groupings with respect to initial weight and rate of gain were made in the same manner as with the steer calves previously discussed. Table 5 shows the average initial weights and gains per day for the groups of Choice and Good heifer calves.

TABLE 5.—Average initial weights and gains per day for groups of Choice and Good heifer calves

Initial weight (pounds)	Feeder grade	Cattle	Average initial weight	Average gain per day			
				Cattle gaining 2 pounds or more daily		Cattle gaining less than 2 pounds daily	
		Number	Pounds	Number	Pounds	Number	Pounds
400 or more.....	(Choice.....	56	441.1	35	2.22	21	1.62
	(Good.....	37	426.8	18	2.33	19	1.47
Less than 400.....	(Choice.....	111	350.1	59	2.15	52	1.70
	(Good.....	86	342.1	39	2.29	27	1.78

INITIAL WEIGHT AND RATE OF GAIN IN RELATION TO CARCASS GRADE WITH TOTAL GAINS EQUAL

Figure 18 indicates that a difference in initial weight within the grade did not influence the carcass grade of the heifer calves when total gains on the finishing ration were equal. Generally speaking, this finding was not in accord with results obtained on the three steer groups. In the group of steer calves, however, which obviously is more comparable with the heifer calves than is either of the other groups of steers, the differences in initial weight were greater than in the group of heifer calves. Furthermore, in the Good feeders of the steer-calf group, when total gain did not exceed approximately 400 pounds, the differences in initial weight were not followed by differences in carcass grade (fig. 7).

Figure 19 shows that a variation in rate of gain within the feeder grade, with total gain constant, did not materially influence carcass grade. The steer calves showed a different result, slightly higher

grading carcasses in that instance being associated with the more rapid gains in the feed lot.

FEEDER GRADE AND TOTAL GAIN IN RELATION TO CARCASS GRADE

Figure 20 shows the relationships between feeder grade, total gain, and carcass grade for the Choice and Good heifer calves. There was a difference of 30 pounds between the average initial weights of the

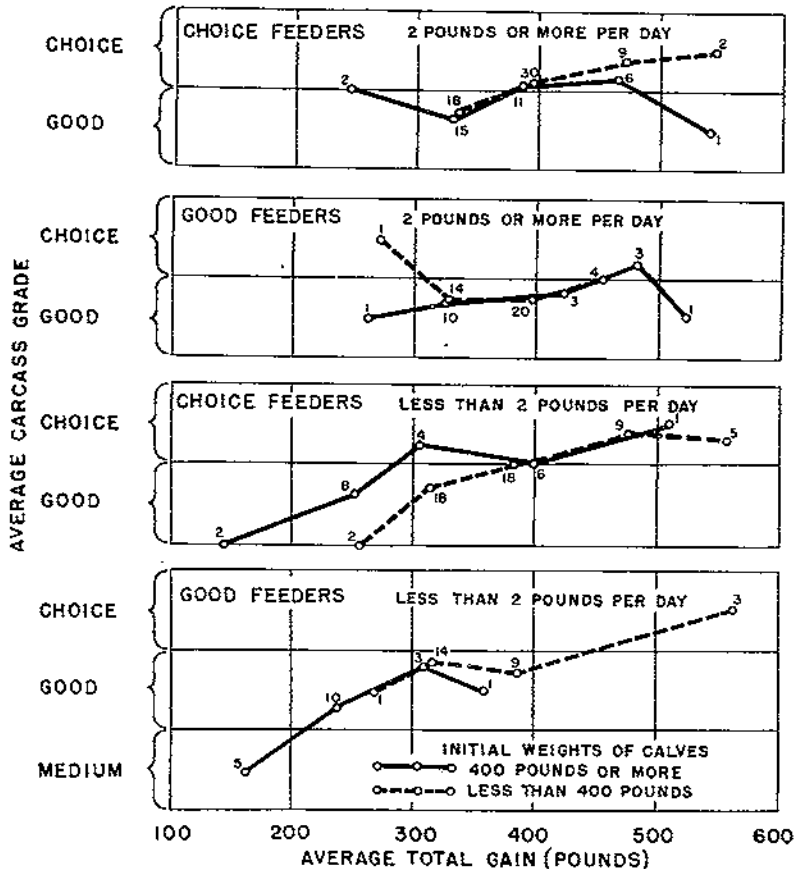


FIGURE 18.—Carcass grades of heifers gaining 2 pounds or more per day and less than 2 pounds per day, as influenced by their initial weights and total feed-lot gains.

two grades of feeders. Some irregularity exists in the two curves, particularly in that representing the Good grade, and this causes some overlapping. With larger numbers and a closer approach to absolute normality the overlapping probably would disappear.

In general, there was a rather small but distinct difference between the carcass grades of the two grades of feeders when total gains were equal. Not taking into consideration the left-hand extremes of the curves—especially the one for Choice feeders—on account of the small numbers involved, the greatest difference shown is about one-third of a grade. After a gain of approximately 475 pounds there

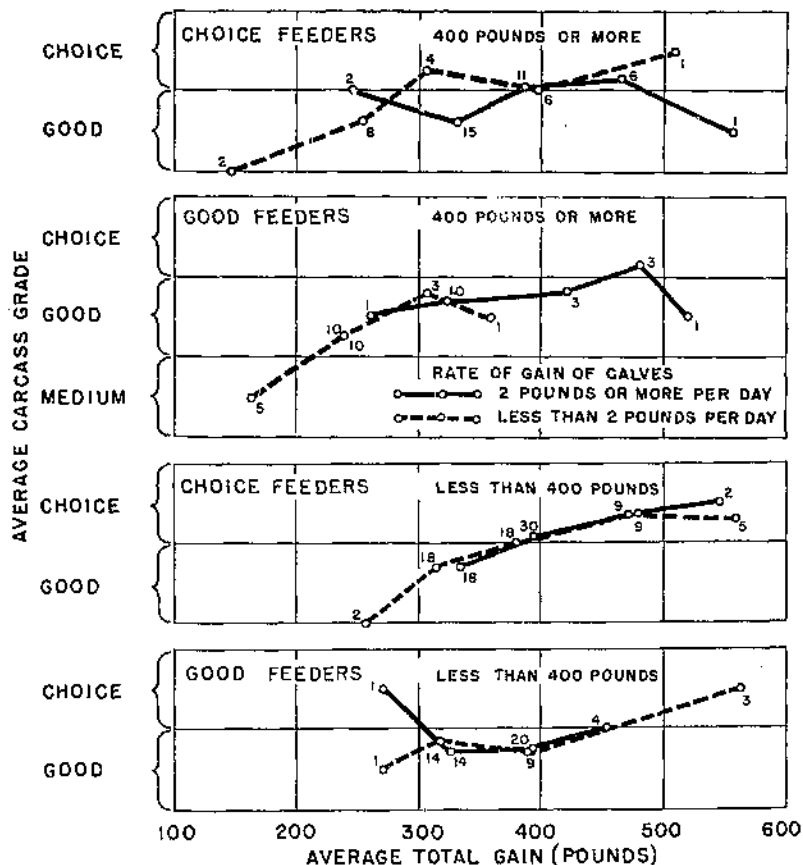


FIGURE 19.—Carcass grades of heifers, with initial weights as calves of 400 pounds or more and of less than 400 pounds, as influenced by rates of gain and total feed-lot gains.

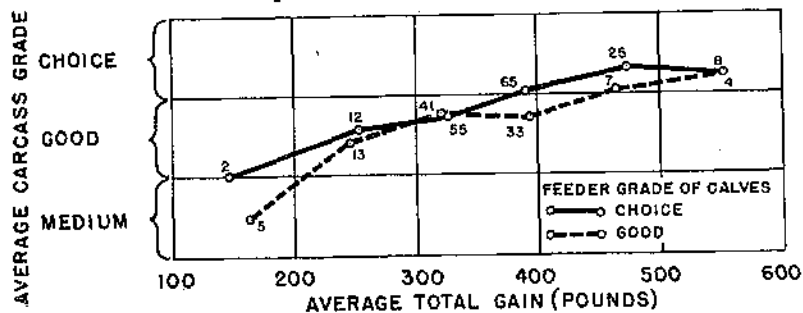


FIGURE 20.—Carcass grades of heifer calves as influenced by their feeder grades and total feed-lot gains.

was a tendency for the increase in carcass grade to proceed more slowly. In fact, a slight decline in carcass grade is indicated with the increase in gain from approximately 475 to 550 pounds by the Choice feeders, but this decline is not regarded as significant, because of the small number of cattle represented.

The Choice feeders produced Choice carcasses after a gain of approximately 380 pounds; Good feeders produced Choice carcasses after a gain of approximately 450 pounds. Good carcasses were produced by the Good feeders after a gain of slightly more than 200 pounds. With an average gain of 162 pounds five Good heifer calves produced average Medium carcasses.

INITIAL WEIGHT IN RELATION TO CARCASS GRADE WITH FINAL WEIGHTS EQUAL

Figure 21 shows the relation of initial weight to carcass grade when final weights were constant. A difference of 91 pounds existed

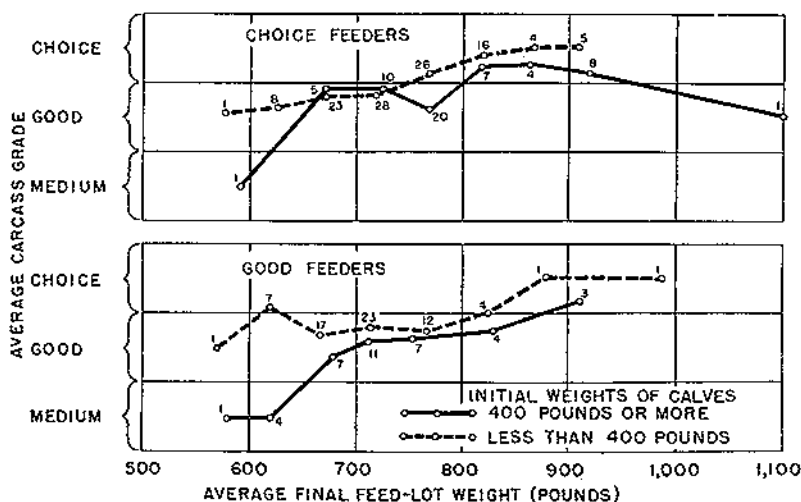


FIGURE 21.—Carcass grades of heifer calves as influenced by their initial and final feed-lot weights.

between the average initial weights of the two groups of Choice feeders and 85 pounds between the two groups of Good feeders.

It is shown that usually higher grading carcasses were produced by calves with the lower initial weights within the feeder grade. The difference is more distinct in the Good than in the Choice heifers. No overlapping of the curves appears in the former. This is in accord with results obtained with steer calves, in which there was less tendency for a difference to appear in the higher grades. In fact, with Fancy, Choice, and Good feeder steers a difference appeared only in the Good grade.

COMPARISON OF HEIFER AND STEER CALVES

Because of the general interest in the relative values of steers and heifers for beef production, comparison is made of the two groups of calves.

Since the 270 heifer calves on which data are available represented only Choice and Good feeder grades, the following comparisons of

the sexes deal only with those two grades. Analysis of the data on heifers and steers showed variations in initial weight and rate of gain within the feeder grade to be associated very little, if at all, with carcass grade. Therefore, they are disregarded in the comparisons of heifers and steers. The groupings and subgroupings of animals of each sex are with respect to feeder grade and final weight, respectively. The ranges employed in making the groupings with respect to the latter are as follows: 550 to 599 pounds, 600 to 649 pounds, 650 to 699 pounds, 700 to 749 pounds, etc. Table 6 shows the average initial weights and gains per day for two grades of heifer and steer calves.

TABLE 6.—Average initial weights and gains per day of Choice and Good feeder heifer and steer calves

Feeder grade	Sex	Cattle used	Average initial weight	Average gain per day
		Number	Pounds	Pounds
Choice.....	Heifer.....	187	389.6	1.93
	Steer.....	592	398.3	2.01
Good.....	Heifer.....	103	372.5	1.99
	Steer.....	227	391.6	1.94

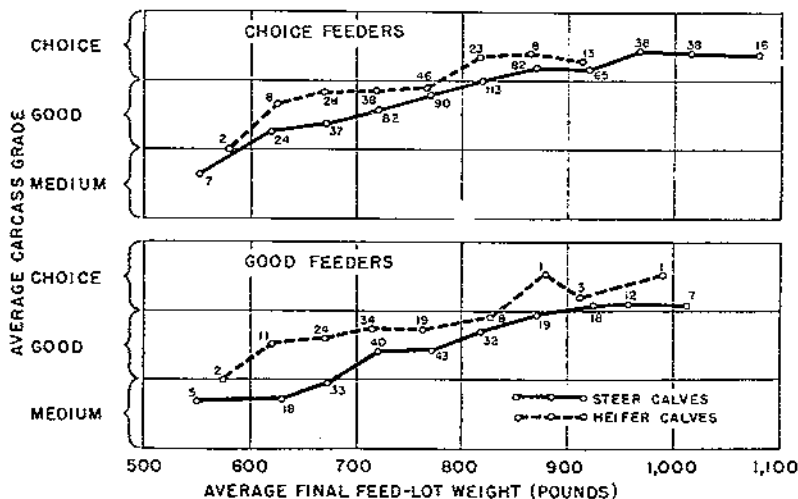


FIGURE 22.—Carcass grades of steer and heifer calves as influenced by their sex and final feed-lot weights.

Figure 22 compares the records of the heifer and steer calves of each of the two feeder grades. With respect to the Choice feeders, table 6 shows differences of only 18 pounds and 0.08 pound between the average initial weights and the average rates of gain, respectively, of the heifer and steer calves. However, figure 22 shows that the heifers consistently produced higher grading carcasses than the steers at equal final weights. The maximum difference was only about one-half grade, but there was a distinct difference in carcass grade throughout the range of from slightly less than 600 pounds to slightly more than 900 pounds of final weight. Assuming a slight smoothing

of the curve for heifers, it is found that they produced Choice carcasses at final weights in excess of about 750 pounds, whereas the comparable steer calves produced Choice carcasses at weights exceeding 820 pounds. A difference between sexes of about 70 pounds in final weight is indicated by these results.

With respect to the Good feeders, table 6 shows that there was a difference of only 19 pounds between the average initial weights and of 0.05 pound between the average rates of gain of the heifer and steer calves. However, figure 22 shows approximately the same general difference between the carcass grades of the sexes as shown by the Choice calves. Up to a final weight of approximately 690 pounds, the difference was somewhat greater than any appearing between the calves of Choice grade. These Good heifers produced Choice carcasses at final weights in excess of about 835 pounds and the steers at weights exceeding 900 pounds, a difference of about 65 pounds. Greater differences in final weight tended to occur at the lower levels of carcass grade.

RELATIONSHIPS SHOWN BY CORRELATION STUDY

A somewhat extensive correlation study was made of the production factors, the grades, and selected grade factors or characteristics of the 2,073 cattle and their respective carcasses. The grade factors included in this study and their definitions are as follows:

Width of feeder body.—Judged at the shoulder, back, hips, rump, and thighs. Width at back and shoulder was observed at a point on the side a few inches below the back line.

Depth of feeder body.—From the top or back line to under line.

Thickness of finish, or external fat, of feeder.—Judged in the live animal by the covering of the back, ribs, loin, pinbones, and rump, and by fullness of flank, thighs, and twist and cod.

Refinement of feeder.—Even, smooth features of the face, top of head, and neck, and smoothness of shoulder, size of head and horns (if present), joints, and bone.

Shape of feeder head.—Determined by the relation between its length and width.

Thickness of flesh of carcass.—Thickness of both fat and lean.

Uniformity of width of carcass.—Width of carcass corresponds to depth of live animal. Uniformity refers to the relative depths at the chuck and brisket, loin and flank, and rump and round.

Thickness of external fat of carcass.—Observed where the forequarters and hindquarters are separated in "ribbing-down" the carcass.

Marbling of lean.—Occurrence of fat particles in the muscle or lean meat. Observed at the cut surface of the large back or rib eye muscle when the carcass was "ribbed-down" or quartered.

Firmness of lean.—Resistance of the lean meat to pressure of the fingers after thorough chilling of the meat and when examined at a cooler temperature of 32° to 38° F.

Color of lean.—Judged by examination of the large back or eye muscle about 30 minutes after the carcass was ribbed-down.

Color of fat.—Judged by examination of the external covering of fat.

Firmness of fat.—Resistance of the chilled external fat to pressure of the fingers when examined at a cooler temperature of 32° to 38° F.

The reader is reminded that the cattle used in this study were a markedly variable group. Grades of feeders ranged from high Fancy to average Inferior. Initial weights ranged from 150 to 1,270 pounds; final weights from 430 to 1,580 pounds. Total gains during the experimental feeding periods ranged from 50 to 710 pounds, and rate of gain from 0.4 to 3.9 pounds per day. The range of slaughter-cat-

the grade was from average Prime to average Cutter, carcass grade from low Prime to average Cutter. In view of the large number of individuals included in the study and the variability in age, sex, breeding, and ration, as previously shown, in addition to the variability here indicated, a high degree of relationship found between any two factors would seem to be particularly significant.

Table 7 shows the coefficients of correlation representing the relationships among 210 different pairs of factors. Detailed consideration is given only to relationships which are of general interest. Those of less general interest and significance are discussed briefly or not at all.

The relationship between initial weight and final weight of these cattle was high (+0.85). Such a result would normally be expected. However, initial weight did not have a highly significant relationship with any of the other factors involved in the study. Attention is directed to the relationship represented by the coefficient, -0.35 , between initial weight and carcass grade. This negative relationship may be somewhat surprising in view of the direct relationship shown between these two factors in the steer calves, yearling steers, and 2-year-old steers. The reason for the difference, it is believed, is that the older, heavier feeders were, in general, fed a shorter period and were not so highly finished as the younger, lighter weight cattle. There were two opposing influences involved in the relationship between initial weight and carcass grade, and the one just mentioned appears to have more than counterbalanced the other, resulting in the negative correlation.

Length of feeding period showed correlations with slaughter-cattle and carcass grades of only $+0.49$ and $+0.48$, respectively. However, slaughter-cattle grade and carcass grade were closely related to each other as shown by the correlation coefficient, $+0.86$, supplemented by figure 23.

Figure 23 illustrates the relationship between slaughter-animal and beef-carcass grades of the individual cattle used in the tests. It shows the distribution of animals by thirds of grades. The figures between the two solid diagonal lines show the number of animals that were graded in the same third of a grade in the carcass as they had been graded alive. The two lines of figures at the right of the center line of perfect correlation show the number of carcasses that were graded one-third and two-thirds of a grade, respectively, above the slaughter grade. The two lines at the left of this center line represent the number of carcasses that were graded one-third and two-thirds of a grade, respectively, below the slaughter grade. Although some of the carcasses were graded at the low third of the grade when the live animal had been graded at the high third of the grade, more than three-fourths of the carcasses were graded the same or within one-third of a grade of the live animal. To be more specific, it was found that 692, or 33 percent, had been graded in the same third of a grade and 969, or 47 percent, were graded within one-third of a grade as carcasses as they previously had been graded as live animals. There were 339 cattle, or 16 percent of the total, that were graded two-thirds of a grade either higher or lower than their respective carcasses. Of the animals that were not graded in the same third of a grade in the carcass as they were graded alive, 39 per cent were graded lower and 27 percent were graded higher than they were graded on foot. Further evidence is thus furnished that

TABLE 7.—Coefficients of correlation showing relationships among certain beef-production and grade factors

Factor	Days on feed	Rate of gain	Initial weight	Total gain	Final weight	Feeder grade	Width of feeder body	Depth of feeder body	Thickness of finish, or external fat, of feeder	Refinement of feeder	Shape of feeder head	Slaughter-cattle grade	Carcass grade	Thickness of flesh of carcass	Uniformity of width of carcass	Thickness of external fat of carcass	Marbling of lean	Firmness of lean	Color of lean	Color of fat	Firmness of fat	
Days on feed	1.00																					
Rate of gain	-.09	1.00																				
Initial weight	-.50	+0.044	1.00																			
Total gain	+.76	+.54	-.41	1.00																		
Final weight	-.11	+.36	+.55	+0.12	1.00																	
Feeder grade	+.44	+.09	-.45	+.44	-.24	1.00																
Width of feeder body	+.43	+.11	-.41	+.44	-.19	+0.96	1.00															
Depth of feeder body	+.42	+.11	-.43	+.44	-.22	+.93	+0.53	1.00														
Thickness of finish, or external fat, of feeder	+.38	+.07	-.36	+.38	-.17	+.94	+.94	+0.89	1.00													
Refinement of feeder	+.40	+.01	-.47	+.35	-.32	+.85	+.81	+.78	+0.80	1.00												
Shape of feeder head	+.43	+.13	-.45	+.45	-.23	+.92	+.90	+.88	+.86	+0.70	1.00											
Slaughter-cattle grade	+.49	+.35	-.39	+.65	-.06	+.71	+.71	+.68	+.68	+.63	+0.69	1.00										
Carcass grade	+.48	+.37	-.35	+.60	+.00	+.69	+.68	+.65	+.66	+.58	+.68	+0.86	1.00									
Thickness of flesh of carcass	+.48	+.36	-.32	+.65	+.02	+.65	+.65	+.62	+.63	+.57	+.64	+.85	+0.95	1.00								
Uniformity of width of carcass	+.49	+.32	-.37	+.64	-.037	+.67	+.67	+.64	+.64	+.61	+.66	+.85	+.94	+0.94	1.00							
Thickness of external fat of carcass	+.44	+.38	-.29	+.63	+.05	+.62	+.62	+.60	+.61	+.54	+.62	+.83	+.95	+.92	+0.90	1.00						
Marbling of lean	+.40	+.38	-.23	+.60	+.10	+.58	+.59	+.57	+.56	+.48	+.59	+.78	+.90	+.85	+.84	+0.88	1.00					
Firmness of lean	+.44	+.29	-.31	+.57	-.01	+.60	+.59	+.57	+.58	+.48	+.58	+.70	+.82	+.78	+.77	+.79	+0.78	1.00				
Color of lean	+.37	+.32	-.33	+.55	+.04	+.55	+.54	+.52	+.53	+.53	+.53	+.70	+.81	+.78	+.77	+.78	+.82	+0.74	1.00			
Color of fat	+.42	+.28	-.41	+.56	-.12	+.59	+.58	+.56	+.58	+.51	+.59	+.70	+.81	+.77	+.77	+.78	+.80	+.75	+0.74	1.00		
Firmness of fat	+.44	+.33	-.34	+.60	+.02	+.61	+.60	+.58	+.59	+.50	+.60	+.73	+.86	+.82	+.80	+.84	+.80	+.82	+.75	+0.81	1.00	

†Coefficients not significant; to be significant, or for probability of 0.05, the coefficients must attain a positive or negative value of 0.043.

the reader may safely consider the results on carcass grade in the foregoing sections of the bulletin as indicative of slaughter-cattle grade. In other words, the various relationships found will be useful to the cattleman as well as to the man who is more directly concerned with the dressed carcass and meat.

RATE OF GAIN AND TOTAL GAIN IN RELATION TO GRADE AND GRADE FACTORS

Table 7 shows that feeder grade and five feeder-grade factors commonly considered, namely, width of body, depth of body, thickness of finish, shape of head, and refinement, all had very low correlation values with rate of gain. This is an important finding because

	CARCASS SUBGRADE														TOTAL			
	PRIME		CHOICE			GOOD			MEDIUM			PLAIN		CUTTER				
	LOW	HIGH	AV.	LOW	HIGH	AV.	LOW	HIGH	AV.	LOW	HIGH	AV.	LOW	HIGH		AV.		
AVERAGE PRIME	1																	2
LOW PRIME	6	5																11
HIGH CHOICE		3	21	25	17	2												68
AVERAGE CHOICE			16	81	91	38	7											233
LOW CHOICE			8	51	109	123	43	5	3									342
HIGH GOOD				15	76	117	69	36	13	2								326
AVERAGE GOOD				3	23	68	97	61	32	9	1							294
LOW GOOD				1	3	25	47	83	70	26	5							260
HIGH MEDIUM					2	5	11	60	82	58	20	3						241
AVERAGE MEDIUM						1	2	18	65	65	22	6						179
LOW MEDIUM							4	11	31	21	9	2						78
HIGH PLAIN									1	3	10	6	4	1				25
AVERAGE PLAIN											1	2	2					7
LOW PLAIN													1	2	1			5
HIGH CUTTER																1		
AVERAGE CUTTER																	1	2
	10	51	174	322	378	276	267	277	194	81	26	6	3	4	2			2,073

FIGURE 23.—Distribution of slaughter-animal subgrades in relation to distribution of beef-carcass subgrades for 2,073 cattle.

feeder cattle grading high in these characteristics usually sell at a premium at the markets. Of the six factors mentioned, shape of head had the highest correlation value (+0.13) with rate of gain, but even this value indicates little relationship. It appears that such value as these characteristics have for the cattleman in selecting feeders lies in their significance as indices of factors other than rate of gain.

The thickness of external fat of the carcass and marbling of lean of the rib eye muscle had the highest correlations with rate of gain. The value in each instance was +0.38. With carcass grade the correlation of rate of gain was slightly lower. It appears, therefore, that rate of gain had only a minor influence on carcass grade or on any of the eight carcass characteristics considered in the study.

Total gain during the feeding period had an important bearing on slaughter-cattle and beef-carass grades.

Six production factors included in the study may logically be considered at this point with respect to their correlations with carcass grade. These are as follows: Feeder grade, +0.69; total gain during feeding period, +0.66; duration of feeding period, +0.48; rate of gain during feeding period, +0.37; initial weight, -0.35; and final weight, +0.0006.

As shown by these correlation coefficients, there was a much closer association of feeder grade and total gain with carcass grade than of the other four factors with carcass grade. In fact, one of the four, final weight, closely approached a zero correlation. The influences of feeder grade and total gain are regarded as having been approximately equal in the average case, and both factors made relatively important contributions to carcass grade.

With the exception of the high coefficient of correlation (+0.85) between final weight and initial weight, all the other coefficients in which final weight was involved were low, some strikingly so.

INDICES OF FEEDER GRADE

Consideration was given to the value of the several feeder-cattle characteristics as indices of feeder grade. The characteristics considered were width and depth of body, thickness of finish, shape of head, and refinement. These were involved in each case, along with a number of other characteristics, in determining the total score representing the grade of the feeder animal as a unit. In view of the fact that all these five factors contributed to, or had a part in each instance in determining, feeder grade, one would expect at least a moderately high correlation between each of them and the grade of the feeder as a unit. This proved to be the case, four of them exceeding 0.90. Of the five factors, width of body was found to be the best index of feeder grade, with the correlation coefficient of +0.96, and thickness of finish the second best.

Table 7 shows further that high degrees of relationship existed among these five feeder-grade characteristics. This would be expected in view of the close association of all of them with feeder grade. Wide feeders, for example, had a marked tendency to be deep and also to carry a moderately thick finish. It is also shown that as an indication of the subsequent grade of the slaughter animal or carcass the width of feeder body, in the average case, was as reliable as the grade of the feeder animal determined by taking all its characteristics into consideration.

RELATIONS AMONG CARCASS CHARACTERISTICS AND CARCASS GRADE

As a final step in the consideration of correlation values it seems appropriate to discuss the relationships between carcass grade and certain carcass characteristics that contributed to it and also to the associations among a few of the carcass characteristics themselves. One is impressed with the importance of thickness of external fat and thickness of flesh as indices of carcass grade, the correlation coefficients in both instances being +0.95.

Marbling of lean, firmness of fat and of lean, and color of fat and of lean were the other carcass attributes considered in relation to

carcass grade. All showed a rather high degree of relationship, the lowest correlation coefficient being +0.81.

The close association of one carcass characteristic with another is noted in several instances. Since they have a common close relation to carcass grade, it is a mathematical necessity that thickness of external fat and of flesh and uniformity of width of carcass be closely related to one another. The coefficients for these and other relationships sufficiently close to be worthy of special mention are as follows:

Thickness of flesh with uniformity of width.....	+0.94
Thickness of external fat with thickness of flesh.....	+ .92
Thickness of external fat with uniformity of width.....	+ .90
Thickness of external fat with marbling of lean.....	+ .88
Thickness of flesh with marbling of lean.....	+ .85
Thickness of external fat with firmness of fat.....	+ .84
Uniformity of width with marbling of lean.....	+ .84
Firmness of lean with firmness of fat.....	+ .82
Thickness of flesh with firmness of fat.....	+ .82
Marbling of lean with color of lean.....	+ .82

As shown previously, in grading thickness of flesh the grading committee considered all flesh, both fat and lean. Thus thickness of external fat was considered alone and also as a factor included in thickness of flesh. The high correlation between thickness of flesh and of external fat is partially explained by this fact. However, the former is regarded essentially as an inherent characteristic, so far as thickness of muscling is concerned, and the latter as one dependent largely on total gain during the fattening period. In addition to the reason given for the high degree of relationship, more extensive feeding of concentrates and greater length of feeding period were employed in many instances with the more heavily muscled cattle, thus taking advantage of their possibilities for finishing as high-grade beef animals.

There was also a close relation between thickness of external fat and marbling of lean. Marbling, although not definitely proved so under experimental conditions, is rather commonly regarded as an index of the degree of tenderness which will be found in the cooked meat. As a factor of quality it receives a great deal of consideration in commercial channels and to an increasing extent among housewives and buyers for hotels, restaurants, and other public eating places. Marbling is normally judged first by inspection of the rib eye after the forequarter and hindquarter are cut apart. However, it is often desirable to have knowledge about the marbling before the carcass is quartered or ribbed-down. Of the characteristics considered in this study, thickness of external fat was most highly correlated (+0.88) with marbling. It appears, therefore, that this characteristic would be useful in predicting the degree of marbling in cases when it is not practical to rib-down the carcasses.

Thickness of flesh and uniformity of width of carcass were also rather highly correlated with marbling. From these results it appears that a beef carcass with a very thick covering of external fat, very thick flesh, and very uniform width may be expected in a great majority of cases to show abundant and extensive marbling.

Firmness of lean was another factor rather highly correlated with firmness of fat, and the latter was closely related to thickness of external fat. The importance of thickness of external fat is again indicated.

The association between marbling and color of lean also deserves attention. Although it is believed that marbling does not necessarily bear any direct relation to the color of the lean tissue itself, these results indicate that abundant fat extensively distributed through the lean does tend to make the latter appear brighter red.

SUMMARY AND CONCLUSIONS

In this study 2,073 cattle were used, varying greatly in age, breeding, grade, rations fed, gains, and other factors. There were relatively large numbers of steer calves, yearling and 2-year-old steers, and heifer calves. Because of the marked variations among the animals, it is believed that they are a good representation of commercial beef cattle.

Results obtained in the study of the steer calves are as follows: With Fancy and Choice feeder steer calves, high initial weight (400 pounds or more) within the grade contributed to higher carcass grade when total gains during the fattening period were equal. Heavy-weight Good feeders tended to produce higher grading carcasses than lightweight feeders after gaining about 400 pounds in the feed lot.

With all grades studied except Fancy, slightly higher grading carcasses were associated with more rapid gains in the feed lot when equal total gains were made.

The heavy, faster gaining feeders of Choice grade, as an example, produced distinctly higher grading carcasses than the light, slower gaining cattle, when total gains were equal.

The higher the grade, among the heavy feeders, the greater was the feed-lot gain required to produce a carcass grade corresponding to the feeder grade. Greater gain was required by lower grade than by higher grade feeders to produce carcasses of equal grade.

The range in carcass grade for the several grades of feeders at any given point of gain was rather narrow, owing largely to greater decline in grade, from feeder to carcass, by the higher grading feeders at the stages of small gains.

Fancy feeders indicated a distinct ability to produce Prime carcasses, but relatively large gains would have been required to produce that result. Choice and Good feeders showed a marked tendency to produce carcasses no higher than Choice, regardless of gains made.

The lightweight steer calves of the several grades showed carcass grades of striking similarity until about 450 pounds of gain was made.

Neither Fancy nor Choice feeders when fed to equal final weights showed a difference in carcass grade associated with a difference in initial weight. Of the two weight groups of Good feeders, the lighter cattle that made the greater gain produced the higher grading carcasses. At final weights exceeding about 800 pounds the differences did not appear significant.

Studies in which the yearling steers were involved yielded the following results:

Both higher initial weight and more rapid gains, within the feeder grade, resulted, in general, in slightly higher carcass grade, when total gains were equal. The influence of more rapid gains was shown especially in the Good and Medium feeders.

Among yearling steers with initial weights of 650 pounds or more the Choice, Good, and Medium feeders produced Choice, Good, and Medium carcasses after gaining approximately 390, 285, and somewhat less than 175 pounds, respectively. The feeders with initial weights of less than 650 pounds required approximately the same gain in each instance as the heavy cattle to maintain grade from feeder to carcass.

The heavy Choice feeders graded average Good as carcasses after gaining about 250 pounds and Good feeders did likewise after gaining approximately 350 pounds. The midpoint of the Good grade in carcass was reached by the lightweight Choice and Good feeders after gains of about 300 pounds and slightly less than 400 pounds, respectively.

High-grade feeders with small total gain declined more in grade, feeder to carcass, than low-grade feeders. A rather narrow range in carcass grade resulted for the several grades of feeders at any given point of gain. It appeared that even high-grading feeder yearling steers must be fed for at least moderately large gains to produce high-grading carcasses.

The lightweight feeders of Choice, Good, and Medium grades produced, in general, higher grading carcasses than the heavyweight feeders at equal final weights. The greater gain made by the lighter weight feeders in each grade more than counterbalanced the influence of the higher initial weight of the other group, under the condition of equal final weight.

Choice 2-year-old feeder steers weighing 850 pounds or more produced, in general, carcasses grading distinctly higher than the lightweight feeders, with equal feed-lot gains. With the Good and Medium feeders differences in initial weight did not appear to influence carcass grade.

Differences in rate of gain among the 2-year-old steers showed little, if any, relation to carcass grade.

The heavy Choice feeders produced Choice carcasses after gaining about 290 pounds. Good feeders required about the same total gain to grade Good in the carcass. The Good and Medium feeders produced carcasses of practically the same grade after gaining about 375 pounds.

The results indicate that about 400 pounds of gain would have been required in the average case by the lightweight Choice feeder steers to produce Choice carcasses. Good feeders made Good carcasses, with a gain of about 320 pounds. As with the heavyweight cattle, the Good and Medium feeders produced Good carcasses after gaining 350 to 400 pounds. Carcass grade did not vary greatly among the several grades of feeders, especially in the lightweight class, at points of equal gains.

A difference of 223 pounds in initial weight did not appear to affect carcass grade at equal final weights, in the case of Choice feeders. The data, however, were limited and not entirely conclusive. The lightweight group of both Good and Medium feeders produced higher-grading carcasses. Total gain during the feeding period, in these two grades, was more important than higher initial weight, when final weight was constant.

In the three steer groups there was a general tendency, indicated most clearly by the Choice grade, for the older steers of a given

feeder grade to produce higher grading carcasses than the younger steers, when total gains were equal. An explanation of this tendency is that with the older animals a larger proportion of the gain is fat or finish which, in meat animals, contributes so greatly to carcass grade. A variation in age of other grades of feeders, however, did not appear to exert an important influence on carcass grade when total gains did not vary.

Among heifer calves a difference in initial weight within the feeder grade did not influence carcass grade when total gains were equal. A difference in rate of gain within the feeder grade did not materially influence carcass grade.

In general, a small but distinct difference appeared between the carcass grades of Choice and Good heifer feeders when equal gains were made. With gains in excess of about 475 pounds, carcass grade tended to increase more slowly than below that point.

Choice and Good feeder heifer calves produced Choice carcasses after gains of approximately 380 and 450 pounds. Good feeders produced Good carcasses after a gain of about 200 pounds.

At equal final weights higher grading carcasses were produced, in general, by the heifer calves in the lower initial-weight group than in the higher initial-weight group. The difference was more marked with Good than with Choice feeders.

Heifer calves of Choice feeder grade produced slightly higher grading carcasses than similar steers at equal final weights. The heifers produced Choice carcasses at weights exceeding about 750 pounds, the steers about 820 pounds.

Good heifer and steer calves showed approximately the same differences in carcass grade as the Choice calves, but up to about 690 pounds of weight the difference was somewhat greater than any appearing between those of Choice feeder grade. Choice carcasses were produced by Good heifers and steers at weights exceeding about 835 and 900 pounds, respectively.

In the correlation study, in which all the cattle were included, the relation between duration of feeding period and carcass grade was represented by the correlation coefficient of +0.48.

Width and depth of body, thickness of finish, shape of head, refinement of feeder, and feeder-cattle grade were not reliable indices of the relative rates at which the animals gained in the feed lot.

Rate of gain did not have an important bearing on carcass grade among the 2,073 cattle, as shown by the correlation coefficient +0.37. Of the eight carcass characteristics considered, marbling of lean and thickness of external fat had the highest correlations (+0.38) with rate of gain.

Feeder-cattle grade and total gain had important influences on carcass grade. These influences were approximately equal in the average case.

Width and depth of body, thickness of finish, and shape of head of feeder were closely related to feeder grade, the correlation coefficient in all instances exceeding +0.90.

Width of feeder body was the best index of feeder grade and refinement of feeder the least valuable. Also, width of feeder body, as an indication of the subsequent grade of the slaughter animal or carcass, was as reliable in the average case as the grade of the feeder animal as a unit.

Thickness of external fat and thickness of flesh of carcass were very closely related to carcass grade.

Thickness of external fat, thickness of flesh, and uniformity of width of carcass were closely related to one another.

Thickness of external fat was the characteristic most highly correlated with marbling. Thickness of flesh and uniformity of width of carcass also showed rather close relationship to marbling. It appears that when there is very thick external fat and flesh and very uniform width, abundant and extensive marbling may be expected in a great majority of cases.

Firmness of lean was rather closely related to firmness of fat and the latter to thickness of external fat. In the case of marbling and color of lean the correlation coefficient was $+0.82$ indicating that abundant and extensive marbling tended to make the lean appear brighter red.

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